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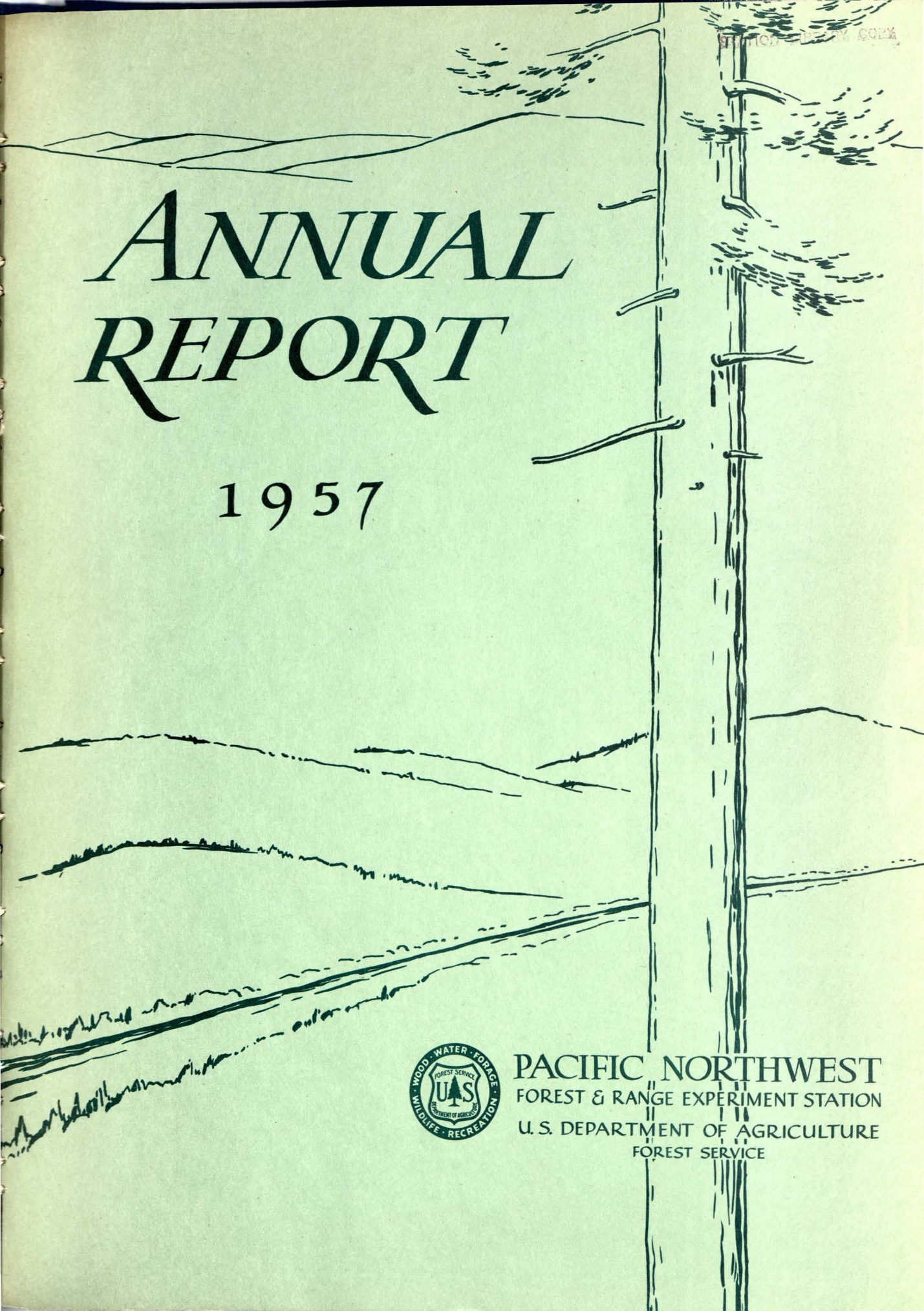

PACIFIC NORTHWEST
FOREST & RANGE EXPERIMENT STATION
U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

RESEARCH CENTER PROVINCES

PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION

● Research Center Headquarters

▲ Experimental Forests and Ranges

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March 1958

PACIFIC NORTHWEST
FOREST AND RANGE EXPERIMENT STATION
R. W. Cowlin, Director Portland, Oregon

FOREST SERVICE U. S. DEPARTMENT OF AGRICULTURE

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Introduction

Protection of forests against loss from destructive agents has long been a matter of prime concern to practicing foresters. More recently the problem has become a matter of public concern in the Pacific Northwest because such losses, and programs attempting to control them, directly affect the regional economy and all forest users. The onset of insect or disease epidemics, conflagrations, severe windstorms, or damaging mammals activates a host of physical and economic forces that greatly complicate the work of the forest land manager and the timber industries.

The full measure of loss from natural causes is not known exactly. Neither can we appraise precisely the cost and benefits of reducing such losses to tolerable levels through direct or indirect control measures.

The principal reason we cannot answer these questions is simply because we do not know enough about these forest enemies. Although we have the benefit of considerable research, programs have not been adequate to fill the many gaps in our knowledge of fire, insects, disease, forest mammals, and climatic factors and their relations to the forest plant community. Because of the urgency of gaining control, much of our research has been directed toward providing immediate but partial answers so that we might devise some remedial measures. We have had neither the time nor the resources, men and facilities to search out the basic problems and solve them through long-range fundamental research programs.

Recent loss estimates, which are admittedly inadequate, give at least a reasonable perspective of the problem. For example, it was estimated in 1952 that the total annual losses in the Pacific Northwest from destructive agencies was 4 billion board-feet (International 1/4-inch scale) of sawtimber valued at 70 million dollars. Not included in these figures are losses occurring from delayed regeneration, reduction of forest growth, damage to the forest site, watershed impairment, and economic interruptions and translocations. All these are attributable to damaging agents but are difficult to estimate, even in rough terms.

In addition to actual losses, the costs of prevention and control programs amounted roughly to 11 million dollars for the Pacific Northwest during 1957.

Perhaps the problem can be defined more clearly by outlining a specific example. An epidemic outbreak of a European insect called the balsam woolly aphid, or Chermes, was discovered in 1954 in Pacific silver and subalpine fir stands of southwestern Washington. This insect is now damaging or killing forest stands on about 600,000 acres in western Washington and western Oregon, involving several billion board-feet of sawtimber. Pacific silver fir ranks third in timber volume in the State of Washington and has been counted on heavily for future raw material for Pacific Northwest timber industries. Subalpine fir stands protect valuable watersheds and are a potential source of commercial timber.

The balsam woolly aphid has created two major problems. One is the immediate problem of forest-land owners and industries of what to do about salvaging killed or damaged timber. The other is how this epidemic can be controlled and future ones prevented. Both of these problems need research. In order to salvage the affected timber, large-scale cutting must take place in forest types about which we know little. Information is needed on growth and yield, methods of cutting to assure regeneration, desirable future stand composition, and rates of deterioration of killed trees in different environments. Since these stands grow on steep upper slopes where snowfall is heavy and soils often thin, watershed values of the affected area are critical. Here again there is a lack of information concerning optimum watershed management practices.

Although Pacific silver fir has been used considerably for pulp, only comparatively small amounts have been cut for lumber and use for plywood is experimental. Use of subalpine fir has been even more limited. Consequently, much more information is needed on utilization of timber products of these species, which would involve many studies. Diversion of a large part of the area's timber output to relatively new industrial species will create many marketing and other economic problems.

Obviously, if the values are to be captured, time will not permit finding answers to this complex of problems before salvage must commence. Some answers of course can be supplied by drawing on other research, and some by short-time studies. But the need for a continuing strong program of applied research is illustrated by these circumstances.

Another and perhaps more critical need is for basic information on the insect and its relation to its host and the forest complex, so that dependable preventive and control measures can be taken. Not enough is known now to commence either direct or indirect large-scale control measures. Based on European and Canadian experiences, attempts at control are being made through importation of predaceous insects. We do know that direct chemical spraying is not effective under forest conditions. Use of systemic insecticides might be a solution, but first we need basic research in this field. It may be possible to develop preventive forest management measures involving genetically resistant individuals or species of fir, but again a program of basic research in forest genetics is needed before actual management practices can be developed through applied research.

The balsam woolly aphid problem illustrates the need for a balanced research program in forest protection, forest management, watershed management, forest utilization, and forest economics. Such a program should have as a foundation a continuing program of basic forest biology research. A staff of scientific specialists equipped with modern equipment and laboratories is required to initiate a basic research program. This problem also illustrates how employment of a coordinated approach using all forest science disciplines is needed to provide information for properly managing and protecting the forest-land resource.

Similar examples could be developed by selecting a disease such as white pine blister rust, or any unusual climatic phenomenon adversely affecting forest values.

The progress we were able to make in 1957, as in preceding years, was increased greatly by cooperation received from many agencies, public and private. Cooperators include individuals, companies, associations, national forest administration, other Federal agencies, State agencies, and educational agencies. Through joint effort, we believe we can make greater progress in 1958 and succeeding years in solving current and prospective forest, range, and watershed problems.

Forest Economics Research

Work programs were broadened during 1957 for the several phases of forest economics research in which the station is engaged. Progress of the Forest Survey inventory program, the major project of the forest economics research division, was accelerated through expanded cooperation in making inventories of national-forest and Indian lands, and through development of a procedure for electronic data processing. Also included in the inventory program was the initiation of studies by Forest Survey and national-forest administration to test the efficiency of a systematic grid of permanent sampling points for determining timber volume and forest area.

Economics research in the fields of forest management, forest utilization, and forest product marketing was organized on a section basis, with a staff of three specialists. A project analysis and program were prepared as a general guide for the station's efforts in forest marketing research.

Additional emphasis was given to studies in aerial photo techniques applicable to forest inventory work in the Pacific Northwest and other western regions (see Techniques Research section).

FOREST SURVEY PROGRAM

Cooperative Working Circle Surveys

In recent years, the Forest Survey inventory program has been very closely coordinated with a related program of timber surveys on national-forest working circles, made by forest administrators for purposes of management planning. In the interest of efficiency and economy, a joint plan has been developed for reinventory of national-forest land by national-forest and station personnel. The reinventory of other forest lands is made, generally concurrently, by the station. The need for early completion of the national-forest, working-circle surveys has largely determined priority in the scheduling of county reinventories. Date of last previous inventory, availability of recent aerial photography, and rate of change in the forest situation due to timber utilization and forest growth are other factors influencing the reinventory schedule.

In 1957, about 2.7 million acres of national-forest timber on 9 working circles was jointly surveyed by national forest administration and the station; some 2 million acres of forest land in other ownerships was covered by station crews. The year's total field coverage of 4.7 million acres is about 9 percent of the region's forest area, a rate of progress needed to assure a 10 to 12-year inventory cycle.

During the year, analyses of inventory results were complete and reports issued for Lane, Lincoln, and Tillamook Counties in Oregon, and for Snohomish County in Washington.

Other Inventory Cooperation

A cooperative agreement was made in the latter half of the year with the Bureau of Indian Affairs for the inventory of the Spokane and Colville Indian Reservations located in Stevens, Ferry and Okanogan counties in northeastern Washington. The Spokane Reservation was inventoried in the fall of 1957 and work will begin on the Colville Reservation in spring of 1958. All work should be completed in 1959.

In the inventory of the Spokane Reservation, location of sample plots was based on a systematic grid with a 1.7-mile interval. Where additional samples were needed for desired timber-volume accuracy, a more intensive grid of 0.85 miles was used. Forest and resource managers of the Bureau of Indian Affairs want a more intensive forest type map of the reservation than is currently made by Forest Survey. As information is also needed on the overstory and understory of forest stands on the area, dual typing is being done.

Systematic Grid for Permanent Plots

During the decade preceding 1957, location of sample plots for timber-volume inventory on all forest lands in the region was based on random selection on aerial photos. Area of forest land by stand-size class and forest type was determined from a 100-percent, in-place type and condition-class map. In 1957, a different procedure of plot location was tried both on the national-forest working circles and on lands in other ownerships. The inventory sample plots, all of which were established as permanent plots for future periodic remeasurement, were located at points on a systematic grid. These grid points were platted on base maps at a basic interval of 1.7-miles or at multiples of 1.7, such as 0.85 or 3.4 miles. Choice of interval depended on desired accuracy of timber-volume estimate.

For areas outside the national forests inventoried by Forest Survey, statistical determination showed that a 3.4-mile grid generally provided about the required number of plots for desired accuracy. This grid locates sample plots for estimation of timber volume, forest growth and timber mortality. Area expansion factors, by stand-size class or geographic sampling stratum, were derived from a complete forest type map.

On national-forest areas, the cooperative inventories were designed to locate plots at points on a systematic grid of 1.7 miles, or multiples thereof that would adequately sample both timber volume and forest area. Area estimates are derived from proportion of plots falling in a particular type, stand-size, or condition class. A standard forest type map is made, for use as a resource management tool only; it is not used for determination of area statistics and expansion of timber-volume data.

Data collected on the national forests during the year will be used for an analysis of the comparative results of area estimation by type mapping and by field plot classification. This analysis will include cost estimates and relative accuracies of both area and timber volume estimates obtained by the two procedures.

Establishment of a systematic grid of permanent inventory sample plots over the forested parts of Oregon and Washington should provide valuable forest trend information in the future. It would also provide opportunity for cooperative forest inventories by various public agencies and private timberland owners. Any agency or owner could efficiently use information from the sample plots falling in the area of interest. A remeasurement, computation, and analysis program could be developed to furnish needed information to all cooperating land managers.

Data Processing Program

A procedure for electronic processing of forest inventory data was developed during the year. Computation of all field plot data collected in 1957 will be accomplished through use of a magnetic drum, data processing machine (see Techniques Research section). Approximately 150,000 trees will provide the data for the first use of this new procedure.

Considerable preparation was required in the development of the procedure. A first step was to design a field plot card that would facilitate the collection of plot data and serve as a suitable source document for the punching of individual tree cards. Programs for the machine operation were then developed for inventory information for both the Douglas-fir and ponderosa pine subregions. A program for computation of forest growth estimates has been completed for the ponderosa pine subregion and will be developed for the Douglas-fir subregion.

Once machine programming is prepared for continuing projects like Forest Survey and working circle inventories, and individual tree cards are punched, computation of a season's data is completed in a very few hours and at small cost.

LANE COUNTY'S FOREST RESOURCES AND INDUSTRIES

Results of a number of studies of the forests and forest industries of Lane County, Oreg., conducted in the latter half of 1956 by the station in cooperation with the county Chamber of Commerce, were analyzed during the year. These studies were made in connection with the regular Forest Survey reinventory of forests in the county.

One major study covered the number, kind, and capacity of the county's forest industries. It showed a total of 141 sawmills active in 1955, the study year, with a combined rated 8-hour capacity of more than 6 million board-feet of lumber. Total production during the year exceeded a billion and a half board-feet of lumber. Nineteen green veneer and plywood plants produced 626 million square feet (3/8-inch basis) of green veneer and 590 million square feet of finished plywood; about a sixth of the green veneer was exported to plywood plants in neighboring counties. A large sulfate pulp and paper plant was an important segment of the industry. This plant's raw material consisted entirely of chips, most of them converted from mill residue and some from defective logs. Other timber processing plants included shingle mills, planing and remanufacturing plants, specialty or cut-up plants, pole and piling yards, wood-treating yards and a central wood-chipping plant.

During 1955, the county's sawmills, green veneer and plywood plants, and shingle mills consumed 1-1/2 billion board-feet (Scribner rule) of logs. Ninety percent of the logs were cut in the county and 10 percent came from neighboring counties.

A total of 1,956,000 tons (dry weight) of plant residue was developed in the manufacture of lumber and plywood in the county in 1955. Seventy percent of the plant residue volume was utilized; 30 percent was unutilized. Of the utilized volume, 27 percent was converted to pulp chips, 4 percent was used in the manufacture of small wooden parts and for agricultural purposes; and 69 percent was used for fuel--industrial, institutional, and domestic--or in the plant boilers. Unutilized coarse residue--slabs, edgings, and trim from sawmills and cores from green veneer plants--and residue used for fuel totaled 688,000 tons, dry weight, a large potential source of raw material for manufacture of pulp or fiberboard.

Forest industries in 1955 provided approximately 85 percent of employment and payrolls of all manufacturing industries and about 52 percent of all employment and payrolls in the county. Forest industries employed an average of 13,000 persons with an annual payroll of 60 million dollars. Value of manufactured forest products totaled 185 million dollars.

Other studies included the pattern of forest-land ownership in the county; the annual volume of timber cut, by ownership source; the volume of unutilized salvable material on logged areas; the volume of net annual forest growth, and opportunities for maintaining and expanding forest industries.

Results of the special studies, together with results of the Forest Survey reinventory of the county's forests, were published in a comprehensive report, Forest Resources and Forest Industries of Lane County, Oregon.

ECONOMICS OF FOREST MANAGEMENT, FOREST UTILIZATION, AND FOREST PRODUCT MARKETING

Price Trends and Relations

An analysis of lumber price trends, begun in 1956 as part of a Forest Service study of price trends and relations for forest products, was continued during the year.

This analysis showed that between 1940 and 1955 the West Coast Lumbermen's Association's average price for Douglas-fir lumber in western Washington and western Oregon, f.o.b. mill, increased from $22.20 to $80.90 per thousand board-feet, an increase of 264 percent. If allowance is made for changes in the purchasing power of the dollar by expressing prices in terms of 1947-49 dollars, the rise in lumber prices between 1940 and 1955 was 68 percent. Lumber price increases are attributed to a large postwar demand, a decreasing supply of available high-quality timber, and higher costs for stumpage, labor, and processing.

The 1955 average price of Douglas-fir plywood was $80.88 per thousand square feet for 1/4-inch A-D interior grade, or 202 percent above the 1940 price. In terms of 1947-49 dollars, this is an increase of 40 percent.

Douglas-fir stumpage prices on national-forest and Bureau of Land Management sales in western Washington and western Oregon increased from $5.20 per thousand board-feet in 1944 to $28.90 in 1955. National forest stumpage sales in the ponderosa pine subregion (all species) brought an average of $4.65 per thousand board-feet in 1944 and $19.19 in 1955.

Farm forest crops can provide an important contribution to farm income. Parts of many farms are better suited to the growing of trees than to any other crop.

Since 1955, however, prices for lumber, plywood, and stumpage have gradually declined, with greatest changes in prices for lumber and plywood.

Forest Products Marketing Research

The station and Oregon State College completed a cooperative study of marketing practices and prices for forest products from farms and small private holdings in western Oregon. Among the marketing characteristics examined were method of finding buyer, method of determining quantity and price of timber, type of cutting, previous experience of owner, method of payment, use of written contract, and extent of assistance by farm forester or other source. In addition, the study undertook to define key factors affecting price, and factors affecting the owner's satisfaction with the sale. Results of the study will be published by Oregon State College.

Christmas Trees

A study of Christmas tree production and marketing was undertaken in cooperation with the Oregon State Board of Forestry, Washington State Department of Natural Resources, and the regional office Division of State and Private Forestry. Each year more Christmas trees come from managed lands, although wild lands still produce the major crop. It is believed that Christmas tree markets (and the marketing process) can be greatly developed and improved, with an important influence on local incomes and on the local economy. To a large extent, this product brings new income from outside the region.

Observations during the course of the study indicate a small number of successful individuals with long experience in both wholesale and retail operations, together with a comparatively large number of inexperienced individuals whose success or failure is often determined largely by chance.

Douglas-fir is still the most popular Christmas tree, but there is a growing consumer preference for different or unusual effects. These effects are gained by use of other species, or by painting or flocking (spraying with artificial snow). Dealers realize a higher profit on true firs and pines and therefore tend to push sales of these species.

"U-pick," or "choose-and-cut" sales, are becoming popular near the principal cities on both private and national-forest areas.

Bringing in the Christmas tree is fun for all the family where "Choose and Cut" sales are available. Growers are finding this an increasingly popular method of marketing Christmas trees, but adequate publicity and road signs are needed to obtain a satisfactory volume of sales.

Lodgepole Pine Resource Analysis

An analysis of the lodgepole pine resource in the western States, with emphasis on the Pacific Northwest, was published in a trade journal article. Area, volume, and ownership of this species was shown and present use and future prospects discussed. Attention was also called to growing markets as an incentive for increased harvesting and management of lodgepole pine stands. Demand is growing for use of this species as lumber, poles, and raw material for fiber products.

Table 1.--Area of commercial lodgepole pine type in the Pacific Northwest, by stand-size classes[1/]

Subregion and State	Sawtimber (11" d.b.h. and larger)	Poletimber (5-11" d.b.h.)	Seedlings and saplings (0-5" d.b.h.)	Total
	Thousand acres			
Ponderosa pine subregion	189	1,320	309	1,818
Douglas-fir subregion	6	140	41	187
Total	195	1,460	350	2,005
Oregon	130	1,226	226	1,582
Washington	65	234	124	423
Total	195	1,460	350	2,005

1/ These figures do not include 439,000 acres of lodgepole pine type in the six northeastern counties of Washington.

Table 2.--Ownership of commercial lodgepole pine type in the Pacific Northwest[1/]

Subregion and State	National forest	Other Federal	Other public	Private	Total
	Thousand acres				
Ponderosa pine subregion	1,265	259	53	241	1,818
Douglas-fir subregion	133	11	4	39	187
Total	1,398	270	57	280	2,005
Oregon	1,112	221	6	243	1,582
Washington	286	49	51	37	423
Total	1,398	270	57	280	2,005

1/ These figures do not include 439,000 acres of lodgepole pine type in the six northeastern counties of Washington.

PLANS FOR 1958

1. Complete field work for Forest Survey reinventory of forests in Grant and Union Counties, Oreg., and Okanogan, Asotin, Columbia, Garfield, and Walla Walla Counties, Wash.

2. Continue the inventory program for the Colville and Spokane Indian Reservations, in cooperation with the Bureau of Indian Affairs.

3. Complete computation and analysis of results of Forest Survey reinventory of Baker, Wallowa, and Wasco Counties, Oreg.; and Skagit and Whatcom Counties, Wash. Prepare statistical reports for these counties.

4. Complete calculation of net forest-growth estimates for 7 central Oregon counties and 3 central Washington counties, all in the ponderosa pine subregion. Release results in a publication for each of the two county groups.

5. Complete a study of methods for determining end-product prices for lumber, plywood, and other manufactured forest products. This will include investigation of seasonal price variation. Results of the study will serve as a basis for improved stumpage-appraisal procedures.

6. Study the economic feasibility of increased utilization of wood residues and little-used species.

7. Continue studies of improved methods for collecting and analyzing forest-land ownership data, and for relating current ownership patterns to future resource development.

8. Complete a study of future production trends for major wood-products industries in Oregon and Washington.

9. Prepare estimates of value and volume of mortality in old-growth Douglas-fir stands, and indicate the potential contribution of old-growth Douglas-fir to the regional economy.

10. Continue marketing studies under the program initiated in 1957. This includes (a) investigation of marketing problems for forest products from small ownerships and (b) a general study of the Christmas tree industry in the Pacific Northwest.

11. Continue studies as needed of the relative importance of forest industries to the local and regional economies.

12. As a guide to management and marketing decisions, prepare an economic analysis of financial maturity in Douglas-fir and other western species.

Forest Insect Research

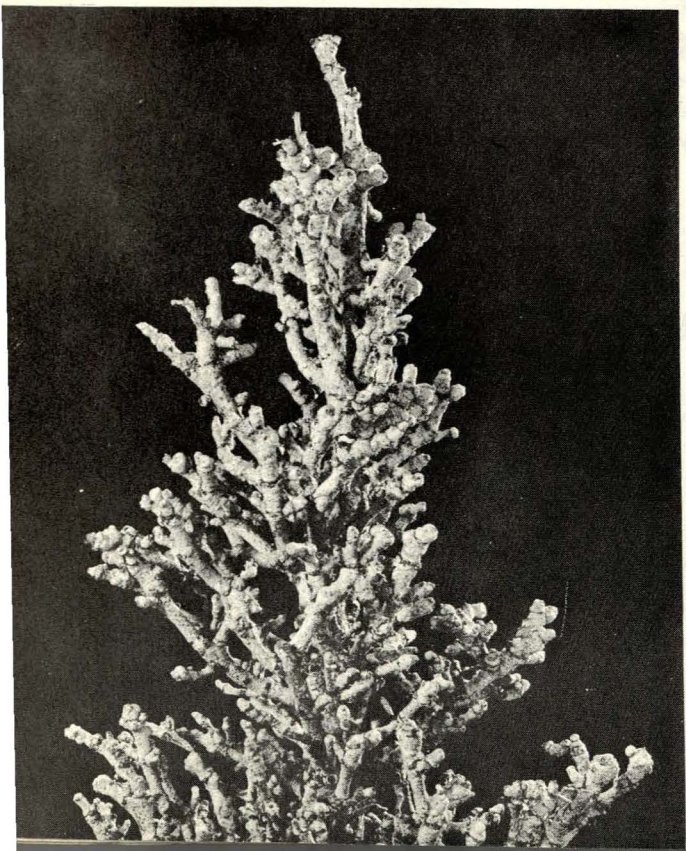
The balsam woolly aphid, an immigrant from Europe, continued to spread and kill true firs in Oregon and Washington, necessitating increased research on it and correspondingly lessened research on other insects. A start toward biological control of the woolly aphid was made by importing one of its insect predators. Also, special techniques were developed and applied in a cooperative survey to determine accumulated damage by the aphid on the most seriously affected area in Washington.

Long-term studies of the spruce budworm indicated increasing effectiveness of natural control, principally by insect parasites. Despite this favorable sign, the accumulated damage and extent of re-infestation revealed by the annual survey called for renewal of spraying on extensive areas in 1958.

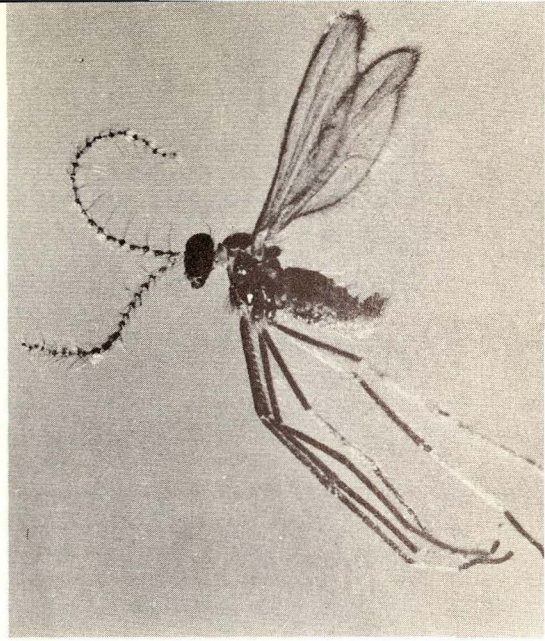
Other developments during the year included: (1) improvement of insect surveys through increased ground checking, (2) initiation of a study of bark beetle diseases, and (3) initiation of a study of insects on browse plants (see Range Management Research section). Research was continued on aerial survey techniques for appraising insect damage, especially that caused by the balsam woolly aphid. (See Techniques Research section.)

BALSAM WOOLLY APHID

Research on insects of the Douglas-fir region was concentrated upon the woolly aphid, to the extent of shifting personnel from other projects. Highlights of progress



Swellings or "gouts" caused by the balsam woolly aphid on the terminal of a subalpine fir.



Aphidoletes thompsoni, a fly that preys on the woolly aphid, has been imported from Europe. (Magnified ten times.)

The fly predators were released in cages on trees heavily infested by the woolly aphid.

made by the station and cooperators were as follows:

1. A 2-year study, financed by the station, was undertaken cooperatively with the Oregon Agricultural Experiment Station to assess the effectiveness of natural control by native insect predators and to develop a program for importing foreign predators.

2. Efforts to control the woolly aphid biologically were begun by colonizing some 1,800 Aphidoletes thompsoni, a predaceous fly from Europe. Liberations were made in the Toutle River drainage of Washington, in the Black Rock area of the Oregon Coast Range, and near Corvallis, Oreg. Although first generation progeny have been recovered from the adults released at Black Rock, it will be a year or more before permanent establishment can be verified, and even longer before the effectiveness of the predator can be determined.

3. A preliminary survey revealed several native predators. Of these, Cnemodon rita--a small fly--was generally distributed and apparently the most important. It seems to be more effective against low populations than against high populations of the aphid.

4. Considerable information concerning the life history and habits of the woolly aphid in the Northwest was obtained. In the milder localities, the insect has up to 4 generations per year, whereas in Europe it has only 2. Thus, the possibilities for increase are much greater here.

5. Plots near Mount St. Helens, Wash., cooperatively established and inventoried by Weyerhaeuser Timber Co. and the station, were reexamined. Little additional tree mortality and crown deterioration had occurred in the Lewis River drainage, but both continued severe in the Toutle River drainage.

General observations showed the aphid populations down on some areas and up on others. For the entire infested area in the two states, the accumulated effects of attack over a period of years continued to show up in heavy killing and in marked deterioration of heavily attacked, but still living trees.

SPRUCE BUDWORM

Investigations of spruce budworm population trends and the natural factors affecting them were continued. Periodic measurements were made on permanent plots in four major infestations, and annual measurements were made on numerous other plots widely scattered over the general area of infestation. Studies of local dispersal of the budworm and of methods for improving the measurement of budworm populations and damage also were continued.

Infestations of recent origin showed a general although modest population increase over 1956. Within these infestations, light populations that were not easily visible from the ground or air in 1956 increased sufficiently to be detected in 1957. Populations of other defoliators of Douglas-fir and true fir were unusually abundant, contributing to the overall damage. The end result was a considerable increase in acreage of defoliation recorded on the annual survey.

Larval populations attacking the opening buds in 1957 in areas under intensive study were about as predicted from egg counts in the fall of 1956. However, the larval populations declined markedly near the end of the feeding period, due in part to parasitism and in part to unknown factors. In three of the four areas under study, egg populations of the 1958 brood were found to be much reduced in comparison with those of the 1957 brood.

Dispersal of budworm populations continued to be related to population density at centers of infestation. Light and moderate populations tend to build up in place, dispersing very gradually into surrounding areas.

A method of sampling has been developed that permits appraisal of population trend in areas for which no previous data are available. Annual sampling for egg masses has shown that the number of old egg masses still adhering to a unit foliage surface approximates the actual number of masses deposited the previous year. Therefore, on foliage samples taken during any one year, the ratio of egg masses deposited that year to the old egg masses on the same foliage may be used to predict trend. This assumes no significant variation in percentage of eggs hatching.

Studies of damage on Douglas-fir showed that in the first year of severe bud-killing, the vegetative buds killed were replaced by an approximately equal number of adventitious buds. While the likelihood of extensive bud-killing is increased when populations are high, the rate of bud development is the most important factor. Severe bud-killing occurs only when shoot growth is retarded after bud-swelling has occurred.

DOUGLAS-FIR BEETLE

Research on the Douglas-fir beetle was considerably curtailed to meet more critical needs on the balsam woolly aphid problem. However, some studies underway for several years were continued cooperatively with Oregon State College and Weyerhaeuser Timber Co.

Mortality caused by the beetle on permanent plots remains very low, probably for lack of forest disturbances such as major blowdowns, fires, or other causes of accumulations of favorable breeding material. Some tree killing is occurring in local areas where heavy infection of Poria weirii root rot and associated windthrow are creating conditions that keep the beetle population high.

Data were summarized from a 1956 study of the relation between amount and location of Douglas-fir blowdown and subsequent killing of green trees by the Douglas-fir beetle. One 320-acre plot was in Oregon; the other (160 acres) in Washington. On the Oregon plot during 1950-55, 6,800 board-feet of Douglas-fir per acre was killed by the Douglas-fir beetle and 2,400 feet was blown down. On the Washington plot during the same period, 5,900 board-feet per acre was killed by the beetle and 2,200 feet by wind. In most cases, the beetle-killed trees were within about 300 feet of the blowdown; in some, they were a quarter of a mile or more away. The results show that (1) mortality by the beetle may seriously deplete a sawtimber stand, and (2) prompt salvage of favorable breeding material is very important in minimizing damage by the Douglas-fir beetle.

SILVER FIR BEETLES

Research on these beetles was prompted by an epidemic that started in 1947 and continued until 1955, when it subsided naturally to its present low level. Studies in 1957 substantiated that the beetles Pseudohylesinus granulatus and P. grandis both have a 24-month life cycle and both lay a second batch of eggs in July or August after first establishing a brood in June. Biological studies of these insects have been terminated and are now being summarized for publication. Some long-term trend plots will continue to be inventoried annually by cooperators through the Northwest Forest Pest Action Council, and the records will be maintained by the station.

SITKA SPRUCE WEEVIL

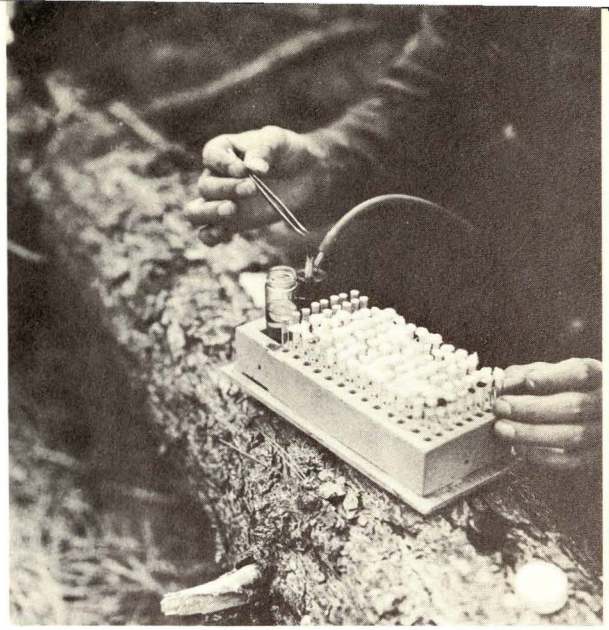
Studies to evaluate the importance of this insect, which kills the leaders of young Sitka spruce, were continued on tagged-tree plots in three locations in northwest Oregon. In a 5- to 8-year-old natural stand at Cascade Head, significant attack occurred for the first time in 1957, when about 2 percent of the trees were damaged. At Tillamook Head, in a 10- to 15-year-old natural stand, about 5 percent of the trees were weeviled--about the same as in recent years, and remarkably few for trees of susceptible age. In this stand, wind and a tip moth, Epinotia hopkinsana, have damaged the spruce leaders more than the weevil. Weeviling in a 30-year-old stand of planted spruce at Youngs River has been tapering off since 1953 (table 3). Further observations are needed to determine whether the trees on this area have grown beyond the weevil-susceptible age, or whether the weevil population has temporarily declined.

Table 3.--Trend of weevil damage at Youngs River, 1949-57

Year	Spruce on plots	Trees weeviled	Proportion weeviled
	Number	Number	Percent
1949	216	6	3
1950	215	18	8
1951	215	35	16
1952	215	52	24
1953	215	76	35
1954	213	27	13
1955	213	27	13
1956	213	18	8
1957	213	11	5

BARK BEETLE DISEASES

Most living organisms are subject to diseases. Over the years, sudden and inexplicable declines in bark beetle outbreaks have suggested that diseases may have been responsible. To investigate this possibility, a study was started by the station in 1957 to identify the diseases of bark beetles and determine their importance.



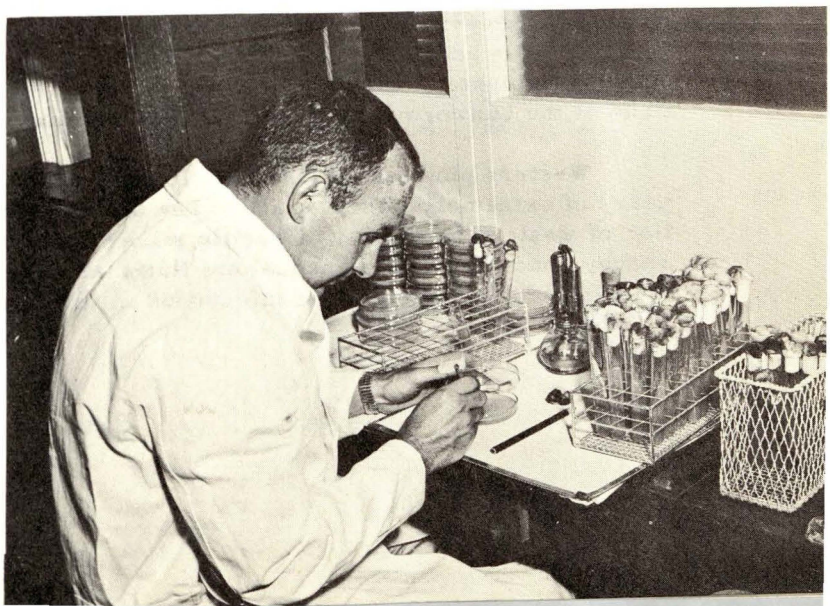
Bark beetles suspected of being diseased were collected from infested trees and placed in sterile vials.

Eight species of bark beetles, infesting various species of pine and fir in Oregon and Washington, were collected. Cultures that were made of the external and internal micro-organisms associated with the beetles are now being studied. In September, the man assigned to the project was temporarily transferred to the California Forest and Range Experiment Station to work with insect pathologists of the Department of Biological Control at the University of California. While in California, he will develop techniques for detecting and evaluating diseases of bark beetles in the West.

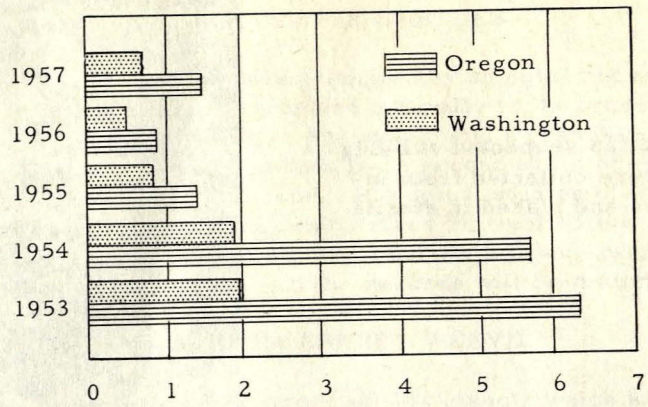
FOREST INSECT SURVEYS

The regional survey followed the cooperative pattern of recent years, with the states of Oregon and Washington and Weyerhaeuser Timber Co. making major contributions to the aerial survey. Many other organizations and companies made ground checks and participated in special surveys. Ground checking was intensified through increased manpower at the station, thus making possible better biological assessment of insect populations.

The extent and severity of forest insect outbreaks in the Pacific Northwest, as revealed by the regional survey, increased in 1957 after three successive years of decline. Epidemic infestations totaled 2, 130, 000 acres, of which 1, 481, 000 (69. 5 percent) were in Oregon and 649, 000 (30. 5 percent) were in Washington.



Culturing bark beetles in the laboratory to determine if disease organisms are present.



Acreages of forest insect outbreaks in the Pacific Northwest for the past 5 years.

Twelve species of forest insects were responsible for the recorded damage in 1957, as follows:

Increasing infestations		Declining infestations
Balsam woolly aphid	Larch budworm	Douglas-fir beetle
Spruce budworm	Western pine beetle	Fir engraver beetles
Black-headed budworm	Engelmann spruce beetle	Mountain pine beetle
Spruce bud moth	Silver fir beetles	Oregon pine ips

The balsam woolly aphid continues to be the most destructive forest insect in Oregon and Washington. Infested acreage of true firs in the two states increased from some 356,000 acres in 1956 to almost 600,000 acres in 1957. The bulk of the infestation is in the Cascade Range of the two states. Severe mortality of sawtimber has occurred in Pacific silver fir stands and in high elevation subalpine fir forests that are non-commercial but of high watershed and recreation value. Salvage programs have been organized by private, State, and Federal owners, but depressed lumber and pulp markets, coupled with the rapid deterioration of true fir, are resulting in a heavy loss of wood.

Surveys in 1957 revealed that epidemic damage caused by the spruce budworm in the central Blue Mountains of Oregon had expanded by 295,000 acres and had increased in severity since the preceding year. Extensive killing of timber appears imminent. In addition, some 35,000 acres sprayed several years previously have become reinfested. In other parts of the Blue Mountain region, scattered infestations of the budworm remain but are not causing serious economic damage.

Western pine beetle losses in localized areas increased sharply after several years of extremely light damage. The black-headed budworm caused severe defoliation of western hemlock and Pacific silver fir in the Washington Cascades. An egg survey conducted in the Snoqualmie National Forest and Mount Rainier National Park indicates a slackening of the infestation in this area in 1958.

SPRUCE BUDWORM CONTROL

For 14 years (1944-57) the spruce budworm has been epidemic in the Pacific Northwest, particularly in Oregon. A 7-year aerial spraying program from 1949 through 1955 controlled the budworm on 3.8 million acres and prevented the destruction of valuable fir resources. This cooperative program, recommended by the Northwest Forest Pest Action Council, was suspended in 1956 and 1957 when survey and research findings showed a reduced threat of tree killing and increased effectiveness of natural control. Based upon survey findings in the fall of 1957, the Action Council has recommended that approximately 812,000 acres (93 percent federal) be sprayed in 1958. Plans are being made to carry out this project.

PLANS FOR 1958

Principal activities by projects will be:

Balsam woolly aphid: Emphasize (1) importing and colonizing of foreign insect predators and (2) assessing the effectiveness of natural control. Continue studies of the aphid and its effects upon host trees.

Spruce budworm: In the expected event that spraying terminates intensive studies of natural control factors begun in 1955, substitute short-term studies of the effects of spraying upon the budworm and associated defoliators. Continue studies of population trends on unsprayed areas.

Douglas-fir beetle: Continue evaluation of causes and amounts of mortality on long-term plots. Begin deterioration analysis of beetle-killed Douglas-fir trees that were reserved for study during the 1950-1953 outbreak.

Silver Fir beetles: Publish accumulated findings.

Sitka spruce weevil: Continue cooperative studies to evaluate weevil damage in Clatsop and Tillamook Counties in Oregon. In cooperation with Crown-Zellerbach Corp. and the Industrial Forestry Association, plant various species and hybrids of spruce to determine their susceptibility to the weevil.

Black-headed budworm: Initiate biological studies to aid in assessing control needs.

Improvement of aerial survey methods: See Techniques Research section.

Surveys: Conduct, coordinate, and report upon (1) the regional cooperative forest-insect survey and (2) special surveys, such as those for balsam woolly aphid, spruce, budworm, and black-headed budworm.

Technical supervision of control: Provide the necessary technical information and guidance for the proposed 812,000-acre spruce budworm control project in Oregon.

Forest Management Research

During 1957 several important changes were made in the forest management research program. Of special interest was acceleration of lodgepole pine management research at the Deschutes Research Center in central Oregon. In years past, lodgepole pine was considered of little value because of its small size. Therefore, relatively little research was devoted to this species. This year, however, a large lodgepole pine pulpmill was constructed at Chiloquin, Oreg., and plans have been announced for construction of another large pulpmill in central Oregon to use lodgepole as well as other species. Because of these developments and because there is more than a million acres of this forest type in central Oregon, demand for information about lodgepole pine and its management has increased many times during the past few years. Thus, increased research in this long-neglected forest type is certainly timely.

In line with recommendations of both local and national-forest research advisory committees, a section of Artificial Regeneration and Soils was activated in the Division of Forest Management Research to help provide a unified approach to the problems of research in seeding and planting, including nursery production, storage and handling of tree seedlings, site preparation, and direct seeding. Greater emphasis will be placed on research aimed at facilitating rapid restocking of cut-over and burned lands by planting and seeding. A project was also begun at the Puget Sound Center to explore methods for increasing productivity of nonstocked and poorly stocked areas through both regeneration and cultural methods.

Helpful cooperation from other public and private groups working in forestry and related fields has continued to strengthen our research program. Even with this help it has been impossible to give many urgent problems the attention they deserve, especially in reforestation and management of the upper elevation mixed-species types.

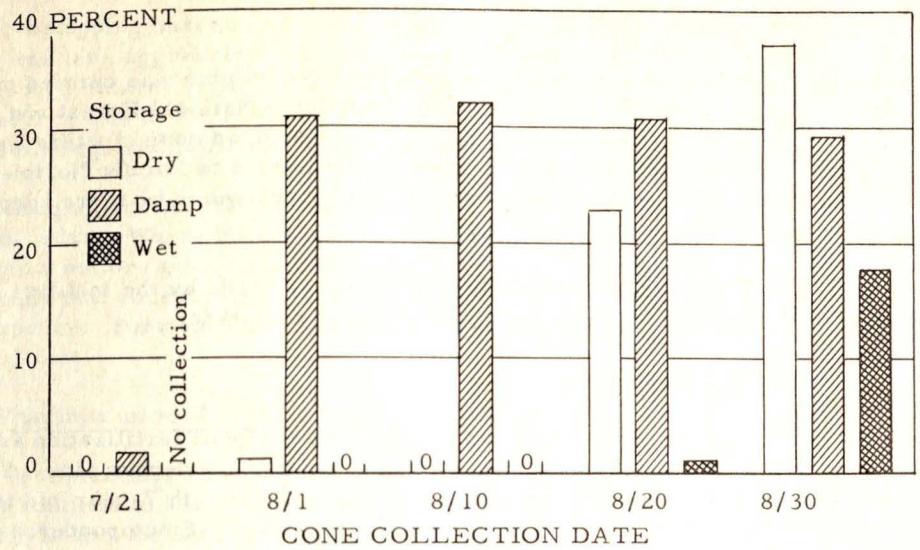
GENETICS

Artificial Ripening of Douglas-fir Seed

Artificial ripening of Douglas-fir seed in early-picked cones now appears possible. Cones picked 20 to 25 days before natural ripening and stored in damp peat moss at about 66°F for 30 to 40 days germinated about as well as tree-ripened seed. The cones retained a fresh appearance and were free of mold for this period. Results of the study open the possibility of extending the cone-picking season.

In the study, cones picked on several dates before natural seed ripening were stored on screen trays under shade in open air, in aerated water, and in the damp peat moss. At each collection date, cones were stored in these three ways. Seed was extracted from all samples the first week in October.

The Oregon Seed Laboratory and the Portland regional office of the Forest Service cooperated with the experiment station in this study.



Average germination percentage of Douglas-fir seed from cones picked before natural ripening and stored under dry, damp, and wet conditions.

Bud Bursting Characteristics of Douglas-fir

The possibility of rigid genetic control of bud bursting characteristics in Douglas-fir is strengthened by a study started in 1955 in cooperation with Oregon State College. Scion material from 6 trees known to have widely different bud bursting dates was grafted onto limbs of 7 Douglas-fir clone trees that originated as rooted cuttings from a single parent tree. Environmental variations between the clone trees were not significant. The scions retained their original bud bursting habits, and limb growth of grafted material was best where bud bursting was earliest.

Test of Introduced Trees

The Wind River Arboretum has long represented the west slope of the Cascade Range as a test area for introduced species. Out of 429 species or varieties (from 12 genera), only one lot of Norway spruce compares favorably in growth with native Douglas-fir. Several exotic pines and larches grew faster in early life than Douglas-fir but after 20 years were surpassed by the native tree. Many fast growing exotics have suffered damage by snowbreak. Occasional extremes of climate (cold, snow, or drought) are largely responsible for reducing the number of species or varieties now surviving to 218. Hardwood species failed so consistently that introductions were discontinued after 1928.

Height Growth of Ponderosa Pine

The average height of planted ponderosa pines at two years showed an excellent statistical correlation ($r = .85$) with the height of the same trees 30 years later. This was shown by analysis of data from five widely scattered "regional races" test plantations in Oregon and Washington.

Crossing Ponderosa and Apache Pine

Pollination of ponderosa pine with pollen from Apache pine was carried on this year near Bend, Oreg., in cooperation with the Deschutes National Forest and the Institute of Forest Genetics, Placerville, Calif. Two hundred cone clusters were pollinated to produce seed for adaptability tests of the hybrid to Pacific Northwest conditions. Ponderosa pine at Bend was used so that stock would be more adapted to climatic conditions in eastern Oregon.

Previous tests of the ponderosa-Apache pine cross made by the Institute of Forest Genetics showed hybrid vigor and good drought resistance.

Fertilizer Test with Ponderosa Pine

A study was started this year at Bend, Oreg., to test soil fertilization as a means of inducing early flowering and stimulating growth in ponderosa pine. Three levels of nitrogen and phosphorus were applied to the soil beneath 7-year-old trees, in a factorial experiment under optimum moisture conditions. Since ponderosa pine begins flowering at about 10 years, results should be available within a few growing seasons.

PLANTING

Ten-Year History of an Oregon Coastal Plantation

A 10-year record of a 6-acre test plantation in the highly productive "fog belt" has shown the need for detailed planning to obtain adequate and prompt regeneration of logged and burned areas. This plantation of Douglas-fir, Sitka spruce, and Port-Orford-cedar was established near Waldport, Oreg., in 1943--seven years after burning slash on the area--to help determine factors affecting growth and survival. Within the 6-acre area, 3 different conditions of brush cover were found, each requiring different treatment.

Results on the study area indicated that the northwest slopes and lower part of the southeast slopes should have been planted immediately after burning so the trees could keep ahead of competing brush and hardwoods. Where brush and hardwoods were aggressive, later follow-up control was also needed to release planted trees

Where overtopped by alder, planted trees were doing poorly.

from overtopping hardwoods. On the upper two-thirds of the southeast slope, where brush was less aggressive, planting accomplished the desired results. On the ridge-top, enough natural regeneration occurred to stock the area, even though the nearest seed source was 2,000 feet away. In this situation, only a little interplanting would have been required to fill in occasional gaps between natural regeneration.

Douglas-fir survived better and grew faster than either Sitka spruce or Port-Orford-cedar. Where brush and hardwoods were aggressive, overtopping competition was a major factor in reducing survival and growth of planted trees. It was also found that rodents and deer preferred Douglas-fir and Port-Orford-cedar to Sitka spruce. Survival at 10 years was 64 percent and average height of planted trees was 6.2 feet.

Test Plantings under Dense Bracken Fern

Test plantings of several coniferous species on the Hemlock Experimental Forest continue to suffer from competition of associated bracken fern. The plantings were begun in 1950 with three nursery grades of Douglas-fir, continued in 1952 with Sitka spruce, and concluded in 1953 with western hemlock. Growth to date is not encouraging, and survival continues in a downhill pattern. Poor thrift of the plantings (table 4) is assuredly a result of the heavy bracken cover--not only directly from vegetative competition, but also indirectly from browsing and clipping by animals that are common in bracken areas.

Table 4.--Survival and height of test plantings on the Hemlock Experimental Forest, 1957

Species and stock grade		Years since planting	Survival	Total height
		Number	Percent	Inches
Douglas-fir	jumbo[1/]	7	47	30.9
" "	2-0	7	47	26.7
" "	1-0	7	60	18.0
Sitka spruce	3-0	5	34	6.4
Grand fir	3-0	5	20	3.8
Western redcedar	3-0	5	47	8.4
Western hemlock	2-0	4	73	7.4

1/ Selected extra-large 2-0 stock.

The need for modified or supplemental regeneration techniques, to ensure restocking on high-site lands that have been invaded by bracken fern, becomes increasingly apparent.

Rabbit Damage to Trial Plantings

Rabbits severely damaged a Douglas-fir test plantation on the Hemlock Experimental Forest in western Washington even though the trees were sprayed with rabbit repellent at time of planting. Damage to the new foliage, unprotected by the repellent,

was sufficiently severe to mask the effect of treatments being tested. The study was established to measure effect of bracken fern control and fertilizer on seedling growth.

Although the study was not designed to rate the incidence of rabbit damage, two interesting correlations were found: (1) Rabbit clipping was most severe where bracken fern was periodically cut away from the trees, and (2) there was a tendency toward more clipping on fertilized trees. The Hemlock Experimental Forest is maintained in cooperation with the St. Regis Paper Co.

Seeding Grass and Planting Pine

Survival of planted ponderosa pine has been little affected by competition from seeded range grasses in a study on the Ochoco National Forest. Seed was broadcast on parts of a clear-cut area in the fall of 1954, and pine seedlings were planted in the spring of 1955. At the end of the third season, tree survival was 59 percent on the grass-seeded area and 67 percent on the unseeded area. A few more deaths were attributed to competition in the seeded area than in the non-seeded, but the total loss charged to this cause (5 percent) was too small to be significant. Animal damage, though severe, was apparently unrelated to grass seeding. Rodents and deer killed 23.7 percent of the trees planted, and 80 percent of those surviving had been browsed.

Several factors may have influenced results of this study. Rainfall was unusually heavy during the first two years, which probably provided ample moisture for both trees and grass. By the fall of 1956, native grasses and other vegetation provided a cover density on the unseeded areas almost equal to that on the seeded areas--15 percent compared with 17 percent. The volume of plant growth, however, was much greater on the seeded areas.

A New Technique for Seedling Culture

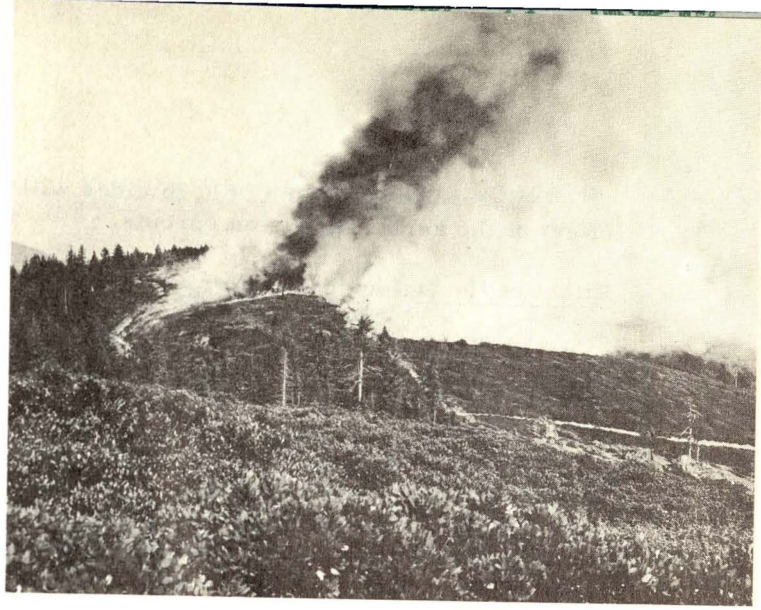
Mycorrhizae are believed to be of great importance in seedling survival and growth, but studies of their effects have often been inconclusive because of the difficulty of preventing contamination by other organisms. In a study established in cooperation with the University of Washington and the Foundation for American Resource Management, a technique has been developed that permits growth of seedlings with tops exposed but with roots protected from contamination. The seedlings are grown from surface-sterilized seed on sterilized soil inoculated with a mycorrhizal fungus. A week after germination, the soil surface is sealed with dimethyl-polysiloxane, a highly viscous fluid that flows slowly over the soil and forms a complete seal in about 24 hours.

BRUSH CONTROL

Brushfield Reclamation in Southwestern Oregon

A single aerial application of herbicides followed by a prescribed burn in brushfields in the Siskiyou uplands does not control the brush to a degree that will allow reforestation. Follow-up treatments are necessary before the area can be planted or seeded.

A test combining chemical sprays and burning has been in progress for two years on the Siskiyou National Forest, where brushfields covering 100 acres were



Prescribed burning of chemically treated brush was tested in southwestern Oregon.

sprayed from a fixed-wing plane in July, 1955. Three treatments were tested: (light) 3 pounds of 2, 4-D per acre, (medium) 2 pounds each of 2, 4-D and 2, 4, 5-T per acre, and (strong) 4 pounds each of 2, 4-D and 2, 4, 5-T per acre. The chemicals were low volatile esters applied in a diesel oil emulsion at a rate of 7-1/2 gallons of spray per acre.

At the end of the following summer, the degree of control was similar on all three areas. Of three major species, a good top kill was obtained on greenleaf manzanita and some dieback occurred on chinkapin and canyon live oak. All three species were resprouting vigorously. Thirty percent of the greenleaf manzanita plants were entirely killed in the light treatment, 15 percent in the medium, and none in the strong treatment.

About 80 acres of the chemically treated brush in the light and medium treatments were burned in September 1956. The prescribed burn removed the almost impenetrable mass of dead brush and killed the new sprouts.

One year after burning, the burned areas contained an average of about 10,000 sprouting shrubs per acre (table 5). The unburned chemically treated area contained a similar number. A sample from undamaged green brushfields in the vicinity revealed a normal density of about 12,000 shrubs per acre.

Table 5.--Number of sprouting shrubs per acre in burned and unburned brushfields in the Siskiyou uplands

Brushfield condition		Sprouting shrubs per acre
Spray treatment	Burned	
None	No	1/ 12,125
None	Yes	13,500
Light	Yes	11,300
Medium	Yes	8,900
Strong	No	10,125

1/ Living plants per acre.

A second application of herbicides will be made during 1958 to determine the effect of the aerial sprays on sprouts.

Effect of Herbicides on Conifer Reproduction

In southwestern Oregon, early fall foliage sprays of 2, 4-D and 2, 4, 5-T are far less damaging to conifer reproduction than midsummer sprays.

Natural reproduction of Douglas-fir, sugar pine, and ponderosa pine was sprayed with low concentrations of 2, 4-D and 2, 4, 5-T during 1956. Treatments were applied during the period of active growth in midsummer and repeated in early fall after height growth was complete and buds were set. The chemicals were applied in three different carriers: (1) water, (2) water plus spreader-sticker, and (3) a 5-percent diesel oil emulsion.

Douglas-fir proved much more resistant than ponderosa pine and sugar pine. Both pines were severely damaged by the midsummer sprays. All three species were injured more by 2, 4-D than by 2, 4, 5-T. During both seasons, damage to the conifers was greatest when the chemicals were applied in the diesel oil emulsion.

The results of this test indicate that chemical release of Douglas-fir reproduction from brush competition may be possible in southwestern Oregon. On the other hand, chemical release of ponderosa pine and sugar pine reproduction without damaging the trees is questionable. Even on Douglas-fir, the herbicides should be applied in water solutions, and the use of oil in the carriers should be avoided.

Sedge Eradication

Long-stoloned sedge (Carex inops) forms dense mats in some old burns and clearcuts on pumice soil at the southern end of the Cascade Range. The sedge competes seriously with conifer reproduction for available soil moisture in such areas.

Two screening tests of herbicides have been made to determine the most effective chemicals for controlling this sedge. In the earlier test, acceptable control was obtained by thoroughly wetting sedge clumps with a 1-percent solution by weight of

Long-stoloned sedge on clear-cut areas makes reforestation difficult.

Dalapon (sodium salt of 2, 2-dichloropropionic acid) in water. The second series of screening tests established during 1956 indicates that TCA (sodium trichloroacetate) may be equally effective.

A test is now in progress to determine the minimum effective dosages per acre for both chemicals.

Chemical Control of Chinkapin

Aerial parts of golden chinkapin (Castanopsis chrysophylla) growing in central Oregon can be killed during the growing season with 2, 4, 5-T as a foliage spray at the rate of one-half pound per acre. When desirable pine trees grow in mixture with this brush species, the brush can be controlled without serious damage to the trees.

Chinkapin sprouting can be delayed and possibly eliminated altogether by a late September foliage spray at the rate of 1-1/2 pounds per acre in an emulsion carrier.

These central Oregon results with herbicides on chinkapin contrast sharply with southwest Oregon experience. There, herbicides did very little damage to the same brush species. Therefore, it is apparent that results of herbicide research in one area cannot be applied in another without verification by local tests.

FIRE RESEARCH

Effects of Slash Burning on Fuel, Soil, and Plants

Slash burning following clear cutting in the Douglas-fir region reduced the area covered by rotten wood, coarse limbwood, bark, and small chunks of logs from 60 percent to 48 percent of the total area and eliminated practically all branches bearing fine twigs. Logs over 11 inches in diameter covered about 12 percent of the area on both burned and unburned areas; however, on many burned areas, logs were burned in two where they crossed, making fire line construction less difficult and heavy fuels less of a hazard in case of future wild fires. Burning increased exposed mineral soil from 22 percent to 50 percent of the total area.

Practically all aerial parts of brush species were dead on the burned area the first season following burning, but live crowns covered 12 percent of the area on unburned plots. However, there was little difference in the area occupied by dense herbaceous cover (11 percent) on burned and unburned areas.

This information was tabulated from measurements taken on 59 pairs of plots. Each burned plot was at least two-thirds blackened by the slash fire to qualify as burned and was located beside the corresponding unburned plot in the same type of slash.

Effects of Slash Burning on Soil Microbiology

Two studies were completed in connection with continuing investigations of the influence of slash burning on forest soil conditions. Both studies dealt with soil microbiology but differed in approach.

One study was aimed at determining whether burning influences mycorrhizal activity in the soil. On severely burned soils, mycorrhizae were found to be reduced

After clear cutting in the Douglas-fir region, a large part of the mineral soil is covered with coarse limbwood, logs, and small chunks of logs (A). Slash fires consume small debris, and logs that remain often burn in two where they cross (B).

for the first 2 years after burning, although they begin to rebuild in number after the first year following the fire. Depth of occurrence of mycorrhizae on the root system was also related to severity of burn for 1-year-old but not for 2-year-old seedlings.

The second study was concerned with changes in soil bacteria, actinomycetes, and fungi after logging and slash burning. Unburned and lightly burned soils were not greatly different in numbers of organisms or ratio of bacteria to actinomycetes. In severely burned soils, however, numbers of bacteria and actinomycetes were strongly increased, as was their ratio. Under the same conditions, the number of fungi was sharply reduced. The findings also suggest that burning had little effect on microbiological activity at a soil depth of more than 1-1/2 inches.

Fire Occurrence and Fire Season Weather Indexes

Three indexes of weather conditions known to be closely related to ease with which fires start and spread have been used for several years in rating severity of fire-season weather west of the Cascade Range summit in Oregon and Washington. Statistical tests have now been made to determine the degree of correlation between these weather indexes and fire occurrence figures.

All three weather indexes were found to be highly correlated with number of man-caused fires, percentage of all fires becoming no larger than one-fourth acre, and percentage of all fires growing to 10 acres or more. The linear equations describing these relations have been determined separately for state and private land and for national-forest lands in western parts of both states. These equations, or similar ones that may be prepared for their own areas, permit fire control agencies to evaluate their actual fire occurrence records in comparison with what might have been expected under the season's weather conditions.

Atmospheric Stability and Forest Fire Behavior

Stability is that property of the atmosphere that accelerates or retards vertical air movement. It is of particular importance to fire behavior since such phenomena as convection, gustiness, whirlwinds, thundersqualls, and slope winds arise from certain conditions of atmospheric stability. Many "blowup" fires acquire their unusual behavior because of stability conditions.

Since the subject of atmospheric stability has not heretofore been presented to foresters, it was fitting that it be included as a chapter in a national fire-weather handbook now being prepared. This station had primary responsibility for the chapter on atmospheric stability and participated in preparation of the chapters on humidity and temperature. The handbook is being prepared under the direction of a joint committee representing the Forest Service, the National Park Service, and the Weather Bureau.

Fire-Season Weather

The annual appraisal of weather during the April-October fire season found near-normal conditions west of the Cascade Range in Oregon and Washington. The spring part of the season was near normal severity, summer was less severe than normal, and fall was more severe than normal. No new records were established, though the fall burning index in western Washington very nearly equaled the existing high record established in 1952. Worst conditions of the season occurred in September, an abnormally hot month with several days of parching east winds.

In comparison with previous years, frequency of summer lightning storms over western Oregon national forests was very low; over western Washington national forests, frequency was slightly above average.

THINNING AND GROWTH FOLLOWING THINNING

Departmental Publication on Thinning Douglas-fir

Substantial progress has been made on preparation of a departmental publication on commercial thinning of Douglas-fir in the Pacific Northwest. A second

revision of the manuscript is now being reviewed by a score of interested foresters of the Pacific Northwest. The bulletin covers theory, practice, and economic aspects of commercial thinning based on 10 years research. It is expected that it will be published in 1959.

Growth of a Thinned 45-Year-Old Douglas-fir Stand

Preliminary analysis indicates that periodic growth of thinned stands equals that of unthinned and that near-maximum growth is obtained from growing stock with 100-150 square feet basal area. This optimum growing stock is at least one-third lower than basal area values shown in normal yield tables. The study, in a 45-year-old Douglas-fir stand, tests three degrees of thinning ranging from 10 to 40 percent volume removal. It is being made on the Voight Creek Experimental Forest in cooperation with the St. Paul and Tacoma Lumber Co. near Tacoma, Wash. Further analysis is now under way.

Spacing of Planted Douglas-fir

Remeasurement of a 32-year-old Site IV Douglas-fir plantation on the Wind River Experimental Forest in western Washington continues to show that wider initial spacings produce larger and taller trees and larger merchantable volumes (table 6). Spacings varying from 4 x 4 feet through 12 x 12 feet are being tested.

Table 6.--Stand characteristics of 32-year-old Douglas-fir at Wind River Experimental Forest, when planted at various spacings

(per-acre basis)

Spacing (Feet)	Total trees[1]	Average d.b.h.[1]	Average height: All trees[1]	Average height: Largest trees[2]	Basal area[1]	Volume: Cubic[1]	Volume: International 1/8-in. rule[3]
	No.	In.	Ft.	Ft.	Sq. ft.	Cu. ft.	Bd. -ft.
4x4	1,790	4.1	38	49	160	3,147	1,232
5x5	1,470	4.2	36	48	137	2,559	1,231
6x6	1,032	4.9	42	53	132	2,752	3,913
8x8	580	5.8	48	59	106	2,409	6,390
10x10	401	7.5	56	65	125	3,211	13,202
12x12	283	8.4	58	66	110	2,892	12,913
4/	681	5.4	39	56	85	1,802	5,311

1/ All trees 1.6 inches d.b.h. and larger.
2/ 5 largest, except 15 largest in 12x12 spacing and 12 largest in the natural stand.
3/ All trees 6.5 inches d.b.h. and larger.
4/ Adjacent natural stand.

As an additional check, height of the five largest trees showed the same significant trend of taller trees for the wider spacings. Basal area decreased with wider

spacing, but board-foot volume increased enormously. Results obtained in this study may help in arriving at the best plantation spacing. Should stocking of under 300 trees per acre prove desirable, many of our poorly to medium-stocked natural stands may have greater potentials than previously realized.

Growth of Dominant Douglas-fir After Release

A "spot" thinning study in a 28-year-old Site IV plantation on the Wind River Experimental Forest in western Washington indicates that dominant trees respond to release, whereas codominants and intermediates do not. In the experiment, 0, 1, 2, and 3 trees were cut around 12 trees each in the dominant, codominant, and intermediate crown classes. Since all trees were spaced 8 x 8 feet at time of planting, the stand was rather open-grown. Average 3-year diameter growth in inches was as follows:

Number of Trees Cut	Dominants	Codominants	Intermediates
0	0.68	0.60	0.45
1	.71	.52	.46
2	.77	.56	.48
3	.79	.59	.42
Average (wtd)	.74	.57	.44

Response of dominants to release closely parallels previously reported results of a similar study in a natural stand. However, lack of response by codominants and intermediates is contrary to findings of the previous study. One possible explanation is that the dominant trees, having larger crowns and supporting root systems, were in competition for nutrients and moisture with surrounding trees, whereas trees in the lesser crown classes were not. Additional experimentation is needed to determine the response of the different types of trees to release, as well as to determine the optimum level of release.

Logging Costs in Thinning Hemlock

First cutting in a test of commercial thinning on the Hemlock Experimental Forest in western Washington has shown that logging costs are not dependent upon volume removed. Four compartments of approximately six acres each were thinned in 1957 for the first time. Thinning treatments are: (1) crown thinning at 3-year intervals, (2) crown thinning at 6-year intervals, (3) low thinning at 3-year intervals, and (4) low thinning at 6-year intervals. Comparison of man-hour and dollar costs per cord for this first thinning includes felling, bucking, and skidding to roadside ready for loading. Loading and hauling cost, being the same regardless of volume handled, is not given. As shown in table 7, costs varied little between compartments.

Dollar costs do not include road costs but cover all other expenses, including supervision, payroll taxes, and general overhead. Skidding was done with a single horse, and all work was by a 4-man contract crew.

Table 7.--Average production costs (felling, bucking, and skidding combined) during commercial thinning operations in young-growth western hemlock

Thinning treatment	Amount cut (per acre)	Proportion of stand cut	Production cost (per cord)	
	Cords	Percent	Man-hours	Dollars
Low (3 years)	8	7	3.36	6.74
Crown (3 years)	10	9	3.76	6.11
Low (6 years)	14	14	3.28	7.08
Crown (6 years)	17	12	3.44	6.68
Average	12	11	3.44	6.69

Thinning Lodgepole Pine

Benefits from thinning lodgepole pine are shown by data compiled in 1957 from sample plots remeasured in 1956 on the Pringle Falls Experimental Forest near LaPine, Oreg. These sample plots were thinned to two degrees (heavy and moderate) in 1934.

The stand was about 55 years old at time of thinning and contained an average of 607 trees per acre. The plot thinned moderately, to the equivalent of a 12-foot spacing, yielded the best net growth (table 8) and also had the highest total and merchantable volume in 1956. Heavy thinning, to a 16-foot spacing, resulted in highest

In a test in central Oregon, lodgepole pine thinned to 16-foot spacing gave higher diameter growth per tree than when thinned to 12-foot spacing.

diameter growth per tree. However, because of severe reduction in growing stock and high mortality from bark beetles, the heavily thinned stand has not grown as much as the moderately thinned stand. Its growth was still superior to that of the unthinned stand over the 22-year period.

Table 8.--Increment on lodgepole pine thinning plots near LaPine, Oreg., 1934-56

(In cu. ft. per acre)

Thinning treatment	Volume after thinning (1934)	Periodic annual increment and mortality		
		Net increment	Mortality	Gross increment
Heavy (16-ft. spacing)	1,228	55	23	78
Moderate (12-ft. spacing)	2,238	77	32	109
Unthinned	2,648	37	53	90

Diameter increment for 22 years on the heavily thinned plot averaged 3.4 inches; on the moderately thinned, 2.4 inches; and on the unthinned, 1.4 inches. Difference in height growth was less marked--only about 1.6 feet greater on thinned than on unthinned plots.

The most notable gain was in the concentration of growth on trees of merchantable size. In 1956, Scribner board-foot volumes per acre in trees 10 inches d.b.h. and larger were: 16-foot spacing, 7,450 bd.-ft.; 12-foot spacing, 9,120 bd.-ft.; unthinned, 3,914 bd.-ft.

Chemical Thinning of Ponderosa Pine

Chemical tree killing promises to make thinning cheap enough to be practical in stands containing mostly medium-sized poles. First attempts at chemical thinning showed that unwanted trees could be killed cheaply but that bark beetles (principally Ips and Dendroctonous monticolae) built up in the dying trees to the point where many reserve trees were beetle killed.

Elimination of the bark beetle build-up was attempted by killing unwanted trees late in the growing season after the main period of insect activity had ceased. Sodium arsenite and amine salts of 2,4-D were the two chemicals used.

Beetle activity was almost eliminated with sodium arsenite treatment in early September. As the 2,4-D formulation kills only during periods of active growth, it was more difficult to kill trees during the period of reduced insect activity. Nevertheless, treatment during late July and August showed some promise of reducing insect attacks on poisoned trees to a safe level. Additional tests must be made, however, before use of 2,4-D can be recommended.

Ponderosa pine spacing-increment study area before removal of the overstory.

Spacing-Increment Study in Ponderosa Pine

The question of optimum levels of growing stock is being given increasing attention in several forest regions. Basic information on stocking is needed as a guide to planting, thinning, and other forest practices. A long-term study of increment and yield in relation to spacing of ponderosa pine was started on the Pringle Falls Experimental Forest in Central Oregon this year. Dense sapling stands will be thinned to five spacings, ranging from 6.6 feet to 26.4 feet. The influence of brush cover upon tree growth will also be measured.

The sapling stand used for study had an overstory of mature trees. Removal of this overstory without excessive damage to young trees required special logging procedures, such as felling trees in specified directions and skidding logs out of plots by use of long cables.

This study is designed to determine the age and size at which stands of various spacings fully occupy the site and produce maximum cubic volume. Further studies will be needed to measure full yields for a series of thinnings such as may be expected under intensive management.

GROWTH, YIELD, AND STAND CHARACTERISTICS

Growth of Red Alder, Conifer, and Mixed Alder-Conifer Stands

A study to determine some factors affecting growth and behavior of mixed alder-conifer, pure alder, and pure conifer stands indicates: (1) that releasing well-spaced conifers by cutting alder is good business, (2) that thinning alder may be of doubtful value, but (3) that release of either conifers or alder may be better than no release at all. This study, on the Cascade Head Experimental Forest in western Oregon, was established in 1935 on abandoned cleared land when 10-year-old stands of alder and conifer were developing. The conifer component included a mixture of Douglas-fir, Sitka spruce and western hemlock. Measurements were made of all trees 6 inches d.b.h. and larger at 5-year intervals through 1956.

The treatments applied and periodic annual growth (including ingrowth) for the last 5-year period were as follows:

Treatment (at age 10)	Periodic Annual Growth (age 25 to 30)
	Cubic feet
Unthinned alder-conifer	244
Unthinned pure alder	266
Thinned to pure alder	249
Thinned to pure conifer	401

Where alder was removed, leaving well-spaced conifers, periodic growth surpassed that of the unthinned alder-conifer stands, as well as that of the thinned and unthinned pure alder stands. The reciprocal treatment, leaving well-spaced alder by removing conifers, failed to yield as much growth as unthinned pure alder. Furthermore, dominant trees in the denser unthinned alder stand developed about as well as those in the thinned stand. While there is still greater cubic-foot volume in the unthinned pure alder stand at age 30, yield of the pure conifer stand is expected to be greater by age 35.

Alder and Soil Nitrogen

The role of alder in soil development was brought out in a study previously reported, which showed that soil nitrogen was 65 percent greater beneath an alder-fir mixture than under an immediately adjacent pure fir stand. Nitrogen content of fir foliage in this mixture was also significantly greater than that of foliage in the pure fir stand. This was taken as indirect evidence of the symbiotic fixation of nitrogen within nodules on alder roots.

In furtherance of this idea, root samples of red alder were provided Dr. G. Bond, University of Glasgow, who for the past several years has carried on intensive experimentation with nodulated, non-leguminous plants. Dr. Bond found that when root nodules of red alder were used to inoculate root systems of other species of Alnus, nitrogen fixation proceeded normally in the newly formed nodules. This adds one more link of evidence that western red alder has the ability to fix nitrogen symbiotically. The practical value of this finding is that some results of European research on the soil-improving role of alder may be extended to our western red alder.

Thinned to pure alder by removal of conifers, this stand failed to match the growth of unthinned pure alder.

Alder Yield Table

Preliminary analysis has begun on 400 sample plots to be used in construction of a yield table for red alder. Response by 50 private and public cooperators has yielded the necessary variety and number of plots required. Coverage has been extended to include both western Washington and western Oregon, thus insuring a more representative sample of alder yields. Indications are that three sites can be recognized.

Completion of analysis and construction of the table is expected by the end of 1958. The project is sponsored by a subcommittee of the Puget Sound Research Center Advisory Committee.

Mortality on Douglas-fir Growth and Yield Plots

Recent remeasurements of 12 permanent growth and yield plots on 3 national forests in western Washington illustrate the influence of mortality on net growth, yield, and management of young Douglas-fir. Periodic gross annual increment per acre, mortality, and ratio of mortality to increment during the past 5 years is as follows:

Table 9.--Periodic gross annual increment and mortality on 12 Douglas-fir study plots in western Washington, past 5 years (per-acre basis)

National Forest	Total plots	Age	Cubic volume			International rule 1/ vol.		
			Gross incr.	Mort.	Ratio	Gross incr.	Mort.	Ratio
	No.	Yrs.	Cu. ft.	Cu. ft.	Pct.	Bd. -ft.	Bd. -ft.	Pct.
Snoqualmie	2	72	252	98	39	2, 148	652	30
Olympic	5	78	185	55	30	1, 329	284	21
Gifford Pinchot	5	114	164	186	114	1, 425	1, 360	95

1/ 1/8-inch kerf.

On the Gifford Pinchot plots mortality exceeded gross increment in cubic feet and amounted to 95 percent by International rule (table 9). This is certainly an untenable situation from a forestry point of view. Even mortality-to-increment ratios of 20 to 40 percent, occurring on the Snoqualmie and Olympic plots, may be approaching marginal economic increment. Two courses of action seem indicated for stands such as these: (1) salvage of, or thinning to forestall, mortality or (2) harvest cutting and establishment of a new stand. These plots and others scattered throughout the region can furnish information that will help evaluate mortality as a factor in determining cutting policy and rotation schedules.

Seasonal Diameter and Height Growth of Douglas-fir

Diameter growth in young Douglas-fir began during the second week of April and ended the first week of September, whereas height growth began during the first week of May and ended the first week of August. Thus, height growth began about a month later and ceased about a month earlier than diameter growth. Some evidence was also found that individual trees that started growth earliest in the spring continued growth latest in the fall. Measurements were made during the 1957 growing season on 15- to 20-year-old Douglas-fir on Simpson Lumber Co. land near the McCleary Experimental Forest in western Washington. Fluctuations in diameter were determined to the nearest 0.005 inch by use of vernier growth bands. Height growth was measured by transit sights from fixed points.

Potential Growth of Lodgepole Pine Under Management

Potential growth under ideal management, as represented by gross cubic-volume increment, has been measured for Deschutes Basin lodgepole stands on 60 plots. Preliminary results from a third of these plots indicate that:

1. Potential growth of lodgepole pine is high. Annual increment was at the rate of 65 to 85 cubic feet per acre on most average site plots under 80 years of age.

2. Gross volume increment showed no appreciable drop until after age 80.

This is the first study under an expanded program of lodgepole pine research at the Deschutes Research Center in central Oregon. A preliminary analysis of lodgepole problems in this area showed that at least an approximation of growth capacity is needed as a basis for further studies and for management decisions.

Estimating Basal Area of Lodgepole Pine with Prisms

Use of prisms for estimating basal area of densely stocked lodgepole pine proved more efficient than the usual diameter measurements on 1/20-acre plots, although more prism measurements were required for the same degree of accuracy. This test was made during studies in eastern Oregon in cooperation with the Pilot Rock Lumber Co. A 4-diopter prism was used.

Under ideal management, potential annual growth of lodgepole pine is high.

Growth of Reserve Ponderosa Pine

Selectively cut ponderosa pine stands on 32 permanent study plots in eastern Oregon have been growing at net rates ranging from -16 to +220 board-feet per acre per year during the most recent period of measurement. Data from the plots represent various methods of partial cutting; from a 14-inch diameter limit cut that left a reserve of 764 board-feet per acre, through various forms of tree and group selection, to a 20-percent cut with a reserve of 17,811 board-feet. The various studies, located on the Deschutes, Malheur, Whitman, and Rogue River National Forests, cover periods of measurement from 10 to 36 years since logging.

Results indicate that over the wide range of conditions sampled, growth of the reserve stand depended not so much on the method of cutting applied or even on the volume of reserve, but rather on the age and vigor of reserve trees and their distribution on the area. These in turn were largely limited by the character of the original stand, although they can, of course, be modified somewhat by the method of marking used.

These historical records largely support the computations of gross growth based on stand structure and volume outlined by Briegleb in the station bulletin, "Calculating the Growth of Ponderosa Pine Forests." However, rate of mortality in most cases has been lower than Briegleb's estimated rate and thus net growth has been somewhat higher. There is also evidence that efforts to get more uniform distribution of reserve trees on the ground pays off in increased growth. Plots in the Rogue River series illustrate this: Allowing for differences in reserve volumes and stand structure, the plot in which special effort was made to improve uniformity of spacing grew from 5 to 27 percent faster than three other plots where spacing was given less consideration.

This ponderosa pine reserve stand is growing at an annual rate of 116 board-feet per acre.

Shelterwood Cutting of Spruce-Hemlock

A shelterwood study at the Cascade Head Experimental Forest in western Oregon is in its second year. Early observations indicate that this method may be useful in establishing regeneration in the Sitka spruce-western hemlock type without brush becoming a major problem. The shelterwood technique may thus provide cheaper means for establishing a new stand than clear cutting, where slash disposal, brush control, and planting is required.

Blowdown, which is often a problem in thinned spruce-hemlock stands, has not occurred even though 60 percent of the original stand volume was removed. The 1956 seed crop produced a million viable seed per acre and the ground is now adequately stocked with 1-year-old seedlings.

Clear Cutting Lodgepole Pine

Observations on lodgepole pine clear-cut areas were made as part of more extensive lodgepole studies in cooperation with the Pilot Rock Lumber Co. These observations provide some useful information for the management of lodgepole pine in the Blue Mountains of eastern Oregon.

Most advance reproduction was Douglas-fir, western larch, and grand fir. In contrast, the reproduction established following logging was largely lodgepole pine, even though occasional seed trees of all four species were present. Overall regeneration was patchy, with stocked areas generally being overstocked. Slash, which covered about 40 percent of the ground, was not burned. By the end of 4 years, most needles and many small twigs had dropped and the slash was well compacted. Additional observations from other studies have shown that lodgepole pine cones in this area are largely non-serotinous and shed seed almost every year. Thus, slash cannot be considered a source of seed for establishing reproduction unless it happens to contain currently ripened seed.

Advance reproduction of western larch under lodgepole pine in the Blue Mountains of eastern Oregon.

These observations suggest that when clear cutting lodgepole pine stands, lodgepole regeneration would be favored by long and narrow or small and irregular clearcuts surrounded by a lodgepole seed source. Slash burning creates a highly favorable seedbed for lodgepole pine, increasing the probability of undesirable overstocking. This problem should be considered when deciding whether or not to burn slash. Other species, when present as advance reproduction, would of course be favored by not burning, by larger clearcuts to reduce lodgepole pine seed available, and by care during logging.

PLANS FOR FOREST MANAGEMENT RESEARCH IN 1958

Plans for 1958 continue to emphasize publication of results from current studies and consolidation of accumulated information into more useful form. Major attention will be given to Departmental publications on management and utilization of red alder, commercial thinning of Douglas-fir in the Pacific Northwest, and reproductive habits of Douglas-fir. The latter will be a revision of a bulletin by Leo A. Isaac published in 1943 by the Pack Foundation. In addition, a summary report of cutting-method studies in ponderosa pine will be prepared for station publication.

The forest management research staff will continue critical review of its present research program, plans and priorities for future work, and research techniques. Additional work will be done on regeneration problems of Douglas-fir on the western slopes of the Oregon Cascade Range. Consideration is being given to use of the Wyssen Skyline Crane for shelterwood cuttings in the spruce-hemlock type of coastal Oregon. Operating plans for the South Umpqua Experimental Forest in southwestern Oregon and the Round Mountain pilot plant management unit in central Oregon will be pushed toward completion.

Forest Utilization Research

Markets for all wood products were soft throughout the year. This has caused considerable unemployment, as half of the Northwest industrial payroll comes from the wood products industry. Plywood prices decreased considerably, causing some companies to close or to curtail production, although output from new companies kept total production 4 percent above that of 1957. Lumber production was down approximately 11 percent from last year, and there was a considerable decrease in pulp production. The decrease in pulp production also affected plywood and sawmill operators, as it resulted in decreased markets for pulp chips produced from residue.

It is expected that market conditions will improve during the last half of 1958. Housing starts are expected to increase by 10 percent over the previous year, which should do much to bolster markets for many wood products.

Poor market conditions have emphasized the need for integration and closer utilization of raw material as a means of cutting costs. Most of the sawmill companies are finding it necessary to install a log barker, chipper, and veneer lathe if they expect to compete for available stumpage. With this equipment they can increase returns by manufacturing veneer from the better logs and some cull logs, and pulp chips from slabs, edgings, and veneer scraps.

Larger companies are integrating a complete pulp mill with their sawmill and plywood operations. During the year, one large sawmill company in this region completed a kraft pulp mill, and a different company is building another. Also, additional particle board plants were put in operation during the year. This trend is encouraging, as more pulp mills and board plants are needed to provide markets for the large amounts of residue still unutilized.

APPRAISAL BASE STUDY

Emphasis was given to a joint project, begun in 1955 with the regional office, timber management division, to develop data for use in appraising national-forest timber. Other governmental agencies involved in selling federal timber are cooperating. The project involves collecting grade-yield recovery data on lumber, plywood, and other primary products manufactured from various species, grades, and sizes of logs. This information, plus production costs and selling prices, is needed to convert the appraisal system from a log selling-price base to an end-product base.

During 1957, four grade-yield lumber-recovery studies were made. The approximately 1,700 logs included in these studies were distributed among 3 species as follows: 160 east-side Douglas-fir, 320 west-side Douglas-fir, 400 sugar pine, and 820 ponderosa pine. Each of the studies, except the one for west-side Douglas-fir, involved recording green-chain grades, drying and surfacing, and recording dry-surfaced grades. A shingle-recovery study was partially completed for No. 2 western redcedar logs.

Assistance was given the Alaska Region of the Forest Service on a lumber-recovery study for Sitka spruce. The Puget Sound Log Scaling and Grading Bureau recently established offices in Ketchikan, Alaska, and logs may now be bought and sold according to bureau rules. Therefore, for appraisal purposes, it is important to know what grades of lumber can be produced from the various sizes and grades of logs. The study, made at the Wrangell Lumber Co., involved getting data on green-chain lumber recovery from 194 logs. As much of the lumber cut in the Alaska mills is shipped out for further manufacture, and as much of it is sold on consumer grades other than those shown in the lumber grading handbook, recovery data from the Alaska study will not have much application in the Pacific Northwest.

Office computation time for recent lumber recovery studies has been shortened a great deal by use of an electronic data-processing machine. A program developed here for this phase of the work is also being used by other western offices of the Forest Service. (See Techniques Research section.)

Seasoning degrade studies were made for west-side Douglas-fir, east-side Douglas-fir, and ponderosa pine to develop information for use in adjusting green-chain recovery data to a shipping-tally basis. In these studies, changes from rough-green to surfaced-dry lumber were classified in detail as to (1) reduction in grade due to seasoning defects, and (2) reduction in volume due to cull and trim.

During the year, the Division of Timber Management of the Regional Office commenced using in current stumpage appraisals, pond-log values developed from recovery data obtained on this project. Methods and techniques for appraising Douglas-fir timber on the basis of end-product recoveries (lumber and plywood), as well as sales-realization tables, were also developed. The station has collaborated with the regional office in application of price data, and it is planned to refine use of the sales-realization tables in 1958.

SKYLINE CRANES

An experimental sale on the Okanogan National Forest to demonstrate the Wyssen Skyline Crane was completed in October. This experiment had been in progress three years and was designed to test the feasibility of logging timber on areas considered inoperable with ordinary equipment. The Wyssen crane, which was developed in Switzerland for logging steep and rocky areas, combines the principles of high-lead logging and aerial transportation. Full advantage of gravity is taken in moving the logs from the mountain slopes to landings in the valleys.

National forests on the east side of the Cascade Range in Oregon and Washington have areas considered inoperable. These areas contain several billion board-feet of timber, which is not included in allowable-cut calculations. Therefore, if a practical means could be devised to log the areas, more timber would be available to industry. This would result in increased employment as well as increased stumpage returns. It is particularly important, therefore, that the Forest Service find a method of logging these presently inoperable areas.

To demonstrate Wyssen's newest and largest machine (3 ton), an experimental sale was made to him near Twisp, Wash., in 1954. Logging started in October of that year with a 4-man Swiss crew. This small crew operated continually, except for winter shutdown due to deep snow.

Four and six-tenths million board-feet was logged on 805 acres. A total of 1,989 man-days was used to yard the logs, averaging 2,300 board-feet per man-day. Included in the yarding time is 403 man-days needed to change the skyline and move the operating machine from one strip to the next.

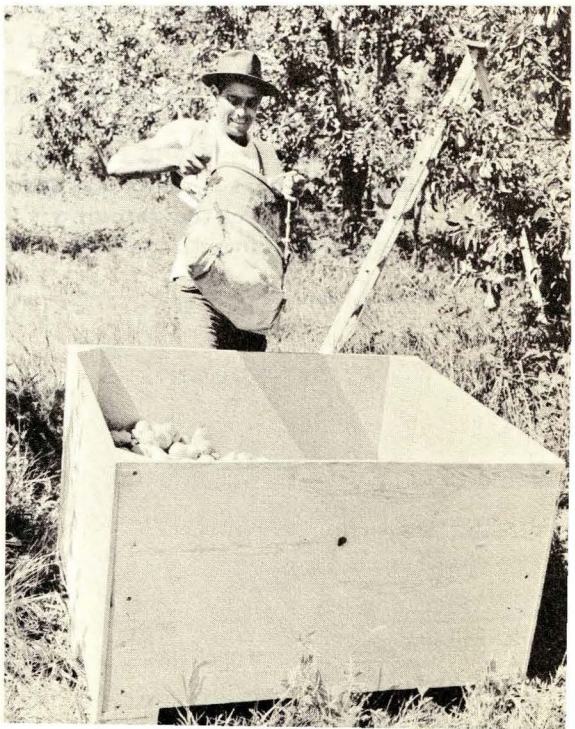
Total skidding costs, including overhead, amounted to approximately $18.50 per thousand, which is comparable to tractor logging costs in the area. Although skidding costs on the Wyssen system are considerably higher than on a tractor operation, the Wyssen system requires far less road development. It has been estimated that approximately 10 miles of road would have been necessary to log the Twisp area with tractors. With the Wyssen system, only 1 mile of road was required.

This experiment has shown that it is feasible to log some of the presently inoperable areas by cable methods. Last summer the supervisor of the Okanogan Forest made a sale of 100 million board-feet of timber, of which 8 million feet was on land previously considered inoperable. The sale agreement specifies that this 8 million feet must be logged with some type of skyline cable system.

In the Douglas-fir subregion also, there is much timber that should be logged by a skyline system. This timber is either located on rocky areas, where road costs are expensive, or on areas where soil erosion would be serious if logged with present equipment. The Wyssen company is now building a 5-ton machine, which is considered heavy enough for logging west-side Douglas-fir. An attempt is being made to have this machine demonstrated in the Pacific Northwest during the summer of 1958. This new machine has an improved carriage, which will make it possible to get considerably higher production.

CONTAINER DEVELOPMENTS FOR FRUIT HANDLING

During the past few years, corrugated fiberboard cartons have been substituted in increasing numbers for nailed wooden boxes as shipping containers for apples. In 1956, approximately 25 percent of the apple crop in the Yakima-Wenatchee area was shipped in fiberboard. In 1957, a greater quantity of fiber-board cartons was used. This trend has created a problem for the growers in that the fiberboard shipping container cannot be used as a picking lug in the orchards because it is not waterproof.



An all-plywood bulk-handling bin for moving hard fruit from the orchard to the packer or storage warehouse. The pallet on this bin is designed for 4-way entry. Assembly is made with drive-screw nails and phillip screws.

Thus, it has become necessary to maintain a larger inventory of nailed wooden picking lugs than was formerly needed, before the fiberboard carton came into the picture. Wooden shipping boxes are also used as picking containers, which reduces the number of picking lugs needed.

A new development in bulk-handling hard fruit was initiated on an experimental basis in the Yakima area in 1956. About 50 palletized bins, each with a capacity of 25 to 30 bushels, were used for moving apples from the orchard to the packer. These bins, which were used in place of picking lugs, were loaded and unloaded with lift trucks.

Acceptance of this new technique by some of the larger growers and packers was virtually spontaneous. In 1957, 7 growers used over 24,000 palletized bins to harvest their crops. More widespread use is anticipated next year in the Yakima area, as well as in other fruit centers in the region. The Forest Products Laboratory and the station are cooperating on equipment design for these bins.

DOUGLAS-FIR DEGRADE STUDY

A study to evaluate kiln drying and manufacturing degrade in producing Douglas-fir lumber was made at the Willamette Valley Lumber Co. at Dallas, Oreg. About 75,000 board-feet of lumber was graded rough-green, sorted, and stacked. Then, under commercial drying schedules in use at this plant the finish grade was kiln dried to a moisture content of 8 to 10 percent and dimension was dried to an average of 18 or 19 percent.

After kiln drying, the lumber was surfaced and regraded. Finally, the amount of fall-down from the original green grade and the reasons for the degrade were recorded. The amount of seasoning and manufacturing degrade developed in typical lumber items in this study is shown in table 10.

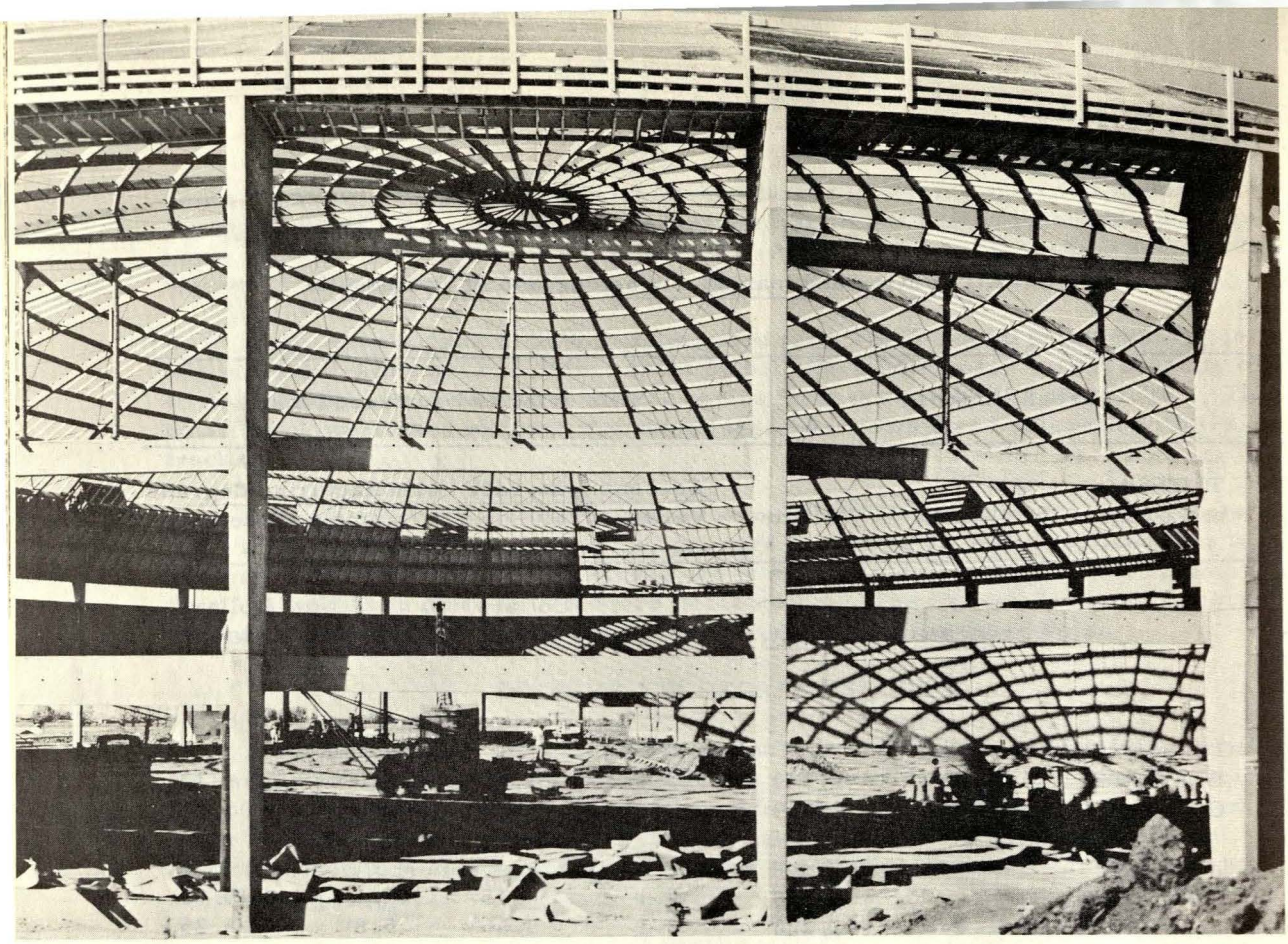
PERFORMANCE OF HOUSE PAINTS

Water-repellent primer, applied to wood siding on houses before painting or repainting, continues to improve paint performance. Painted wood siding in the Pacific Northwest suffers considerable paint failure by blistering and peeling. Much difficulty of this type can be attributed to wind-driven water entering by capillary action at the horizontal lapped joints and at the end joints, causing the siding to become wet behind the paint. The application of water repellents at these joints reduces the capillary action and the wood remains dry.

Of several house installations under study in the Pacific Northwest, the oldest is one in which redcedar bevel siding was dipped in toxic water-repellent primer before it was applied to the house and painted. The paint, of a type regularly used by house builders, shows no failure from blistering or peeling after 4-1/2 years' service. Parts of the same house with the same paint, but not pretreated with water-repellent primer, continue to blister and peel.

Table 10. --Kiln drying and manufacturing degrade in Douglas-fir

Thickness and grade	Green lumber: Width	Green lumber: Volume	Kiln dried and surfaced lumber: Seasoning degrade: Volume	Kiln dried and surfaced lumber: Seasoning degrade: Value loss	Kiln dried and surfaced lumber: Manufacturing degrade: Volume	Kiln dried and surfaced lumber: Manufacturing degrade: Value loss
	Inches	Bd. -ft.	Percent	Dollars per M	Percent	Dollars per M
4/4:						
VG Flooring:						
B & Better	4	2,349	3.9	$ 1.47	8.0	$ 4.15
C	4	2,369	2.6	1.82	7.3	5.51
FG Finish:						
C & Better	6	4,468	4.1	4.15	15.1	10.70
	8	2,226	3.1	3.66	5.8	5.25
	10	1,283	11.0	11.61	2.4	3.00
	12	1,324	7.8	13.01	6.0	7.84
8/4:						
Dimension:						
Sel. Str.	4	1,415	3.6	0.81	2.3	1.01
	8	3,547	4.5	1.13	9.3	3.84
	12	6,104	4.1	1.44	1.9	0.50
Construction	4	2,697	2.8	0.57	3.5	0.89
	8	4,288	4.8	0.76	2.2	0.62
	12	5,660	4.8	1.18	0.5	0.15
Standard	4	1,696	2.6	0.85	1.3	0.39
	8	4,016	0.4	0.12	0.0	0.00
	12	3,568	1.9	1.02	0.1	0.09
Utility	4	2,280	0.8	0.30	0.4	0.18
	8	4,275	0.0	0.00	0.2	0.09
	12	3,876	2.9	0.77	0.0	0.00



Framing for a field house at Bozeman, Mont., in which glued-laminated arches of Douglas-fir were used. These arches, which cover a span of 300 feet, were glued at Portland, Oreg. (Photo courtesy of Timber Structures, Inc.)

LAMINATING

Inspection of glued-laminated arches and posts in two bridges in Oregon showed glue bonds still in good condition after several years of service. A highway and railroad bridge of Douglas-fir at Culp Creek, Oreg., built in 1949 of resorcinol glued-laminated arches, pressure treated with creosote, showed no failure of glue joints or weather checking. Although exposed to the weather and a heavy load of traffic, the glue bonds are fully satisfactory and the creosote has protected the wood against decay and checking. At Loon Lake State Park, Oreg., a highway bridge was built in 1948, using glued-laminated Douglas-fir arches and posts. The lumber in the arches was pressure treated with Wolman salts before laminating. During nine years' exposure to the weather, the glue bonds showed durability; the preservative treatment prevented decay but permitted development of weather checking, normal for unpainted wood in all-weather service.

Laminating structural-wood members into curved shapes is relatively new in the United States, but each year has seen the fabrication of larger members. In 1957, some Douglas-fir arches were produced to cover a clear span of 250 feet and others for a dome with a span of 300 feet. Douglas-fir has been used almost exclusively for glued-laminated structural members, but interest in combining other species with Douglas-fir is increasing and laboratory studies are under way to evaluate the practical usefulness of such combinations.

HIGH-QUALITY VENEER FROM PRUNED DOUGLAS-FIR

A veneer-recovery study was made on logs cut from Douglas-fir trees pruned in 1937 on an experimental thinning plot at Kugel Creek in Washington. After 20 years of growth following pruning, eight trees were cut and ten 4-foot peeler blocks were taken from them for veneer cutting. Tree diameter averaged 14.4 inches at the time of pruning and 19.9 inches when cut in 1957.

Following commercial practice, the veneer was cut into 1/10-inch thickness. Cutting was done on a 4-foot lathe at the Buchanan Lumber Co., Olympia, Wash. It was observed that 8 to 10 years of wood growth after pruning was sufficient for complete knot occlusion but that an additional 7 to 9 years was required to produce clear veneer of face quality. Also, taper in the bole of the tree resulted in the appearance of knots in veneer at the bottom end of the bolt earlier than at the top. This effect was quite pronounced in the 4-foot bolts used in this study. The 8-foot bolts commonly used in industry would probably require 5 to 10 years of additional growth before knot-free veneer could be recovered in the full 8-foot length. The knot-free veneer produced from the wood grown following pruning was of excellent quality but contained the normal amount of pitch pockets, which are usually patched to qualify the veneer for face grade.

DECAY IN COLD DECK STORAGE

A study on the benefits of continuous water sprinkling of wester hemlock logs stored in a cold deck at Salem, Oreg., has been completed. The sprinkling effectively prevented progress of decay over a period of two years. In fresh, sound logs the development of incipient, intermediate, and advanced decay over a 2-year period amounted to only 1 percent in a sprinkled deck compared with 24 percent in the conventional unsprinkled deck. In old logs, containing decay when placed in the deck, water sprinkling also effectively retarded the development of additional decay.

It is believed that incipient decay has little effect on pulp yield. However, intermediate decay reduces pulp yield appreciably, and advanced decay areas result in a total loss. Estimated on this basis, loss in pulp yield due to decay is still much greater in unsprinkled decks than in sprinkled decks (table 11).

Table 11.--Estimated loss in pulp yield of western hemlock logs due to decay during storage, sprinkled and unsprinkled decks

Log condition when decked	Volume loss (percent)	
	Decked 1 year	Decked 2 years
	Sprinkled	
Green	0.3	0.3
Old	0.9	3.7
	Unsprinkled	
Green	0.1	4.0
Old	0.9	13.6

PLANS FOR 1958

Work in forest utilization research during 1958 will be much the same as in the past, as most projects are of a continuing nature. Close relations will be maintained with industry, the U. S. Forest Products Laboratory, Oregon Forest Products Laboratory, Washington Institute of Forest Products, and other institutions doing research in wood utilization. Major emphasis will be given to the following projects:

1. End-products timber appraisal base study.
2. Lumber grade-recovery studies for pine and associated species in the ponderosa pine subregion.
3. Degrade developed in drying and surfacing lumber of various species in both the Douglas-fir and ponderosa pine subregions.
4. Logging methods suitable for areas now considered inoperable.
5. Laminating and uses for laminated products.
6. Improved kiln drying methods.
7. Pulping and chemical utilization, particularly for wood residue and little-used species.
8. Improved wood and wood products containers.
9. Utilization of western hardwoods for pulp, lumber, veneer, and other products.
10. Exterior paint problems in the Pacific Northwest.

Range Management Research

The year 1957 marked the first full year's research in an expanded range and game forage program. Another highlight was the beginning of research in insect-range plant relations. A physiological study of shrubs also was started in central Washington.

Big-game habitat studies are now in progress on both deer and elk ranges in Oregon and Washington. Phases of these studies include livestock-big game relations, habitat management and improvement, ecological requirements of game forage plants, and methods of sampling vegetation on big-game ranges.

MANAGEMENT OF LIVESTOCK RANGES

The study of deferred-rotation and season-long grazing by cattle at light, moderate, and heavy rates was continued on the Starkey Experimental Forest and Range for the fourth year in cooperation with Cunha Bros. ranch of Echo, Oreg. Herbage production and soil cover were reinventoried on 1 of 2 blocks of experimental ranges, but the data are still to be compiled and analyzed. However, a summary of cattle weight gains is available for three summer seasons of different growing conditions.

Seasonal weight gains of heifers and steers grazed on the open range at Starkey were recorded for the first time. Also, the advantages of hauling water for range cattle were summarized for a U.S.D.A. leaflet.

Weight Gains of Cows and Calves

There were no significant differences between cattle weight gains under deferred-rotation grazing and gains under season-long grazing. Yet, as in previous years, light and moderate grazing under both systems of management produced higher average gains of cows and calves than heavy grazing (table 12).

Cattle weight gains were lighter in 1957 than in either 1956 or 1955. The progressively decreasing gains in these years probably were associated with duration of the green forage period. In 1955, the year of heaviest gains, rainfall in late July extended the green forage period on grasslands well into August. The last effective rainfall in 1956 was in mid-June; although an unusually abundant forage crop was produced in that year, forage was cured by late July. In 1957, distribution of precipitation was even less favorable than in 1956 and the principal forage species on grasslands were dry by mid-July. The increased fiber and decreased crude protein content associated with dry forage may be largely responsible for the reduced cattle gains in 1956 and 1957.

Steer and Heifer Weight Gains

Forty-eight yearling heifers that grazed on the open range at Starkey Experimental Forest and Range gained an average of 1.32 pounds per day during the first half of the grazing season, June 20 to August 20. At midseason, all of the cattle

Table 12. --Weight gains[1/] of cows and calves on mountain summer range in eastern Oregon, 1955-57

(In pounds)

Class of stock	Year	Grazing intensity			Average
		Light	Moderate	Heavy	
Cows:	1955	87	74	55	70
	1956	57	58	29	46
	1957	29	16	6	15
Calves:	1955	208	196	180	193
	1956	206	197	179	192
	1957	191	189	181	185

1/ Average of two systems of management: deferred-rotation grazing and season-long grazing.

were rotated to the unused half of the range. From midseason to October 15, the heifers averaged 0.33 pound daily gain.

Weight gains of 50 steers grazed on a separate range unit during the first half of the season averaged 1.70 pounds per day. At midseason the steers were turned out on fresh forage with the open-range cattle. During the last half of the season the steers lost 0.14 pound per day. Most of the steers and heifers were from the same parent herd, with initial starting weights of 619 and 637 pounds, respectively.

The heifer gains illustrate that only 20 percent of the season's gain is made after midseason. The unexplained loss shown by the steers emphasizes the possible value of segregating classes of animals for most efficient production.

Hauling Water for Range Cattle

The advantages of water hauling on arid western ranges were summarized from information gathered in central Oregon, Utah, Arizona and Colorado. Hauling, especially in areas where natural stock water is scarce or is poorly distributed, provides a dependable supply in dry seasons. Water hauling also permits more uniform use of forage, reduces trailing damage to the range, and permits grazing at the most appropriate time.

A 1,000-gallon tank truck is most frequently used by western ranchers. The water is hauled from the original source to storage tanks or directly to troughs on the range. Storage facilities for a week's supply of water are desirable. The best system of direct watering, from the standpoint of maintaining range condition, consists of a group of rectangular troughs that can be moved whenever forage in their vicinity has been sufficiently used.

Although cattle will travel greater distances, tanks or troughs should be spaced not more than a mile apart on flat or undulating terrain. A closer spacing is desirable

if the tanks can be moved frequently. Several temporary watering locations for 25 to 50 cattle are better than a single watering place for 200 or more head.

One livestock association, through local experience on ponderosa pine summer ranges on the Deschutes National Forest in Oregon, has set the following water requirements: 15 gallons per day for a cow and calf; 10 to 12 gallons for mature cattle and 2-year-olds; and 7 to 8 gallons for yearlings.

Oregon ranchers estimate the cost of hauling water at $1 to $1.25 per animal per month when hauling distance does not exceed 8 to 15 miles for a round trip in moderately level country.

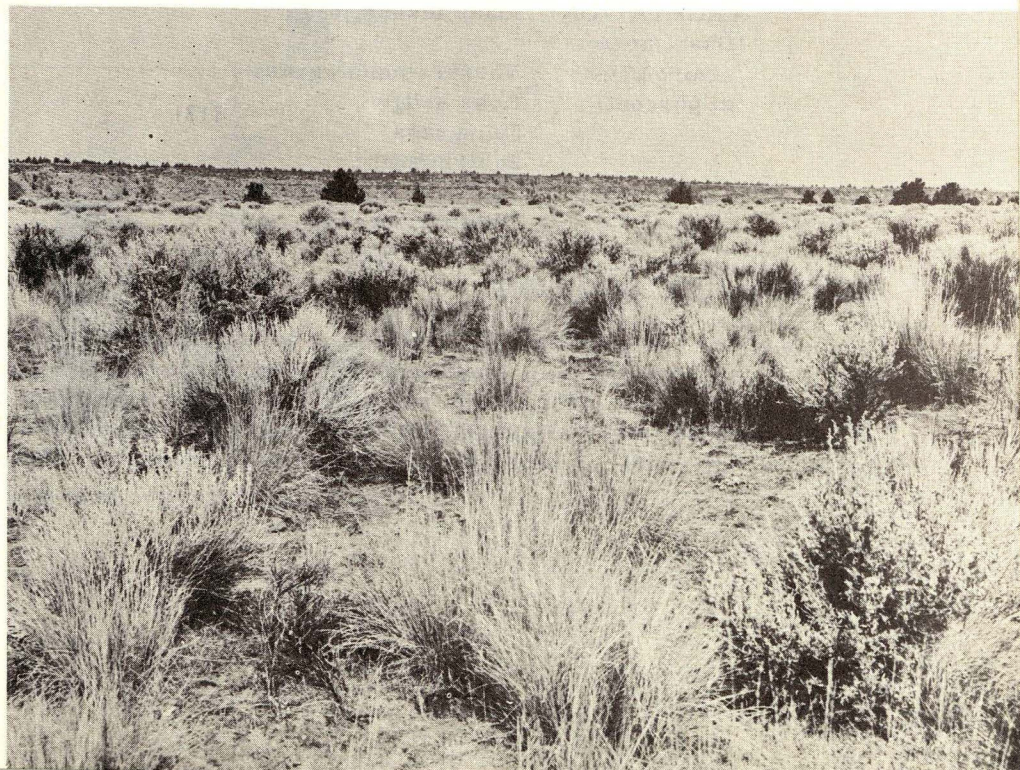
Water hauling gives opportunity for constant checking of livestock condition and degree of forage use. When proper vegetation use has been achieved, water can be hauled to new areas, thus making the difference between mediocre and efficient use of the range.

RANGE CONDITION

Sagebrush-Juniper Grasslands

In central Oregon, inventories of vegetation and soil-site conditions have been completed for two ungrazed areas in the sagebrush-juniper-grass type. Important vegetation and soil-site characteristics were found that definitely distinguish the plant communities on these areas and form a new basis for preparation of range condition standards for the type.

Sagebrush-juniper-bunchgrass range on an isolated plateau in central Oregon. Vigorous clumps of bluebunch wheatgrass comprise 43 percent of the vegetation composition and big sagebrush only 2 percent. Note the paucity of juniper, usually so abundant on central Oregon ranges.



Some of the principal characteristics of these communities are as follows:

	Area 1	Area 2
SITE:	Level plateau at 2,600 feet elevation. Annual precipitation, 8 inches.	A northeast slope at 4,350 feet elevation. Annual precipitation, 10 inches.
SOIL:	Silty clay loam derived from basalt with a clay layer at 9-inch depth.	Shallow sandy loam derived from basalt with a clay layer at 12-inch depth.
VEGETATION: (Basal area composition, in percent)	Bluebunch wheatgrass (43)	Bluebunch wheatgrass (18)
	Western needlegrass (15)	Idaho fescue (13)
	Sandberg bluegrass (10)	Sandberg bluegrass (8)
	---	Threadleaf sedge (9)
	---	Junegrass (14)
	Big sagebrush (2)	Big sagebrush (5)
	Juniper -- widely scattered	Juniper -- widely scattered

Ponderosa Pine-Shrub Range

The best condition ponderosa pine-bitterbrush-bunchgrass range that has been found to date in central Oregon can be briefly characterized as follows:

SITE:	Ponderosa pine timbered range at 4,750 feet elevation. Annual precipitation, 15 to 17 inches.
SOIL:	Coarse sandy loam, derived from pumice.
VEGETATION: (Basal area composition, in percent)	Idaho fescue (63)
	Thurber needlegrass, Ross sedge, Junegrass, Squirreltail (13)
	Bitterbrush (13)

Ponderosa Pine-Grass Range

Factors for determining (1) condition and (2) trend in condition of some ponderosa pine ranges in the Blue Mountains are being evaluated through analyses of data from six range units subjected to various systems and degrees of use on the Starkey Experimental Forest and Range. Herbage weight is being used to determine changes, by 3-year intervals, in herbage composition and production. Measurements of

vegetation cover and soil surface characteristics are obtained by an adaptation of loop-transect and point-analyzer techniques to circular plot work. Herbage utilization is determined by annual surveys.

Soil survey information from experimental range units will also soon be available and is expected to be helpful in interpretation of range condition and trend. The soil survey is being conducted by the Soil Conservation Service.

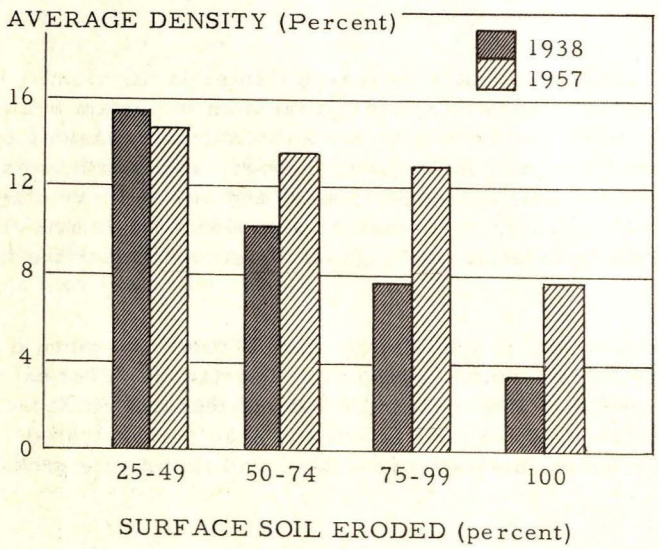
Lodgepole Pine-Bitterbrush Game Range

The permanency of productive bitterbrush stands under a lodgepole pine canopy in central Oregon has not been determined. However, ranges with this conifer and shrub combination are believed to persist for several years and they provide considerable deer cover and forage. Some of the better ranges sampled at 4,800 to 5,000 feet elevation have provided the first information for development of a tentative range condition standard. The soil (LaPine series) on these sites is a loamy coarse sand derived from pumice and varying in depth from 37 to 48 inches. Herbaceous vegetation is sparse, occupying only 2.5 percent of the ground surface. Of this, Thurber needlegrass made up 24 percent of the composition and forbs made up 9 percent. Bitterbrush accounted for 30 percent of the understory.

Subalpine Grasslands

Studies started in 1938 show that vegetation on eroded subalpine range in the Wallowa Mountains recovers very slowly. Sixty-two areas in Tenderfoot Basin were remeasured in 1957 as a joint project of the Blue Mountain and Mid-Columbia Research Centers and the Wallowa-Whitman National Forest.

On protected and non-eroded sites, density of green fescue range averages 45 percent. However, much of the basin was abused by mismanaged bands of sheep before and during 1938. Heavy or poorly timed utilization, and displacement of vegetation by frequent trailing of bands, resulted in reduction of plant cover and large losses of the erosive soil. An average of not less than 25 percent of the ground surface was eroded on areas of the basin not protected from sheep overuse.



Vegetation density on eroded subalpine range in 1938 and 1957.

Grazing management was improved after 1938 through deferred use and conservative stocking. Hence, during the following 19 years some vegetation has recovered. Small shifts in species composition have occurred on various sites, but more striking changes have occurred in amount of total plant cover on study plots where 50 percent or more of the area was eroded. Condition of cover on these sites was found in 1957 to be approaching the condition of sites where only 25 to 49 percent of the plot surface was eroded. Changes in total plant cover on the latter areas over the 19-year period have been nonsignificant. Apparently any further recovery of vegetation density on eroded areas will be relatively slow.

SAMPLING AND TECHNIQUE STUDIES

A method of "nested" sampling for range vegetation studies is being tested in central Oregon. The method, patterned after one used by the range management department at Oregon State College, involves four transects of small plots per nest or cluster. Principal observations on the small, 1-by 2-foot plots are ocular estimates of ground cover by each species present. Additional observations are of (1) crown spread of shrubs, by line intercept, and (2) crown spread of trees, by Lemmon's spherical densiometer. A procedure combining this sampling and measurement technique with detailed soil examinations is being tried as a means of studying vegetation and soil-site relations in four different plant communities: ponderosa pine-bunchgrass-bitterbrush, lodgepole pine-bitterbrush, and two exposure classes of juniper-sagebrush-bunchgrass. Preliminary results are encouraging and the system appears to be sufficiently sensitive for characterizing vegetational units and relating them to soils and sites.

Another technique study, on the use of a modified loop-transect procedure for measuring various ground cover and soil surface characteristics, has been completed and a manuscript on the subject submitted for publication.

INSECT-RANGE PLANT RELATIONS

A cooperative project with Oregon State College to study insects that attack range plants in Oregon was started in 1957. The study is an important one since there is evidence that insects may destroy more vegetation in some localities than livestock and big-game animals combined. Information on insects associated with our important browse plants is virtually nonexistent.

The study was centralized at the Deschutes Research Center in the vicinity of Bend, Oreg., with emphasis on an inventory of insects present on important browse species and bunchgrasses. The broad aim is to determine the impact of insects on: bitterbrush, curlleaf cercocarpus (mountain-mahogany), rubber rabbitbrush, western juniper, big sagebrush, Idaho fescue, Thurber needlegrass, and one or more other grasses in east-central Oregon. In addition to intensive collections in this area, insects were collected at about 50 other locations throughout the state to make the inventory as complete as possible.

An estimated 80 species of insects, representing about 45 families, were collected in numbers indicative of at least potential economic importance. Most of these were associated with bitterbrush. The destructiveness of tent caterpillars (Malacosoma pluviale) and an unidentified looper has already been demonstrated. Eight additional species are sufficiently abundant and widespread to indicate probable destructiveness.

Nest of tent caterpillars (Malacosoma pluviale) on bitterbrush.

Insect damage to shrubs is caused by gall formers, defoliators, juice suckers, fungus-growth inducers, twig girdlers, and root feeders. Relations between attacks of these insects on grazed plants and use by grazing animals will require much investigation. However, a start was made during the year in gathering this information.

Flat-headed borers were found attacking bitterbrush of low vigor, characteristic of overgrazing. Also, two families of insects that feed on the roots of bitterbrush were usually found in certain soils of ponderosa pine-bitterbrush-bunchgrass communities. Weevils were most abundant in a coarse sandy loam, the Shanahan series. May beetles were most abundant in the coarse sands of the LaPine series, where they fed on root tips.

This preliminary study has indicated the need for evaluation of factors that lead to insect damage. The study should be extended to other host plants. Also, a more intensive inventory of mite populations is needed.

Elk sedge: An evergreen, rhizomatous, grass-like plant. It produces 30 percent of the available forage in open forest-range types of mountain summer ranges in eastern Oregon and eastern Washington.

ECOLOGY AND PHYSIOLOGY OF RANGE PLANTS

Elk Sedge

Removal of various amounts of current year's herbage from elk sedge has, for the first time in 4 years of study, resulted in significant differences between treatments. Prior to 1957, 60-percent herbage removal had only resulted in significantly fewer and shorter seed stocks than those developed by plants subjected to 20- and 40-percent clipping intensities. However, in 1957, the 60-percent intensity of clipping resulted in 31 percent less herbage than for the 40-percent intensity. No significant differences in herbage production could be shown between the 20- and 40-percent treatments. These results have occurred regardless of the date of treatment.

Bitterbrush

First steps have been taken in investigation of the physiological patterns of bitterbrush, a key shrub in the management of deer range. The study theme is to determine the cyclic level of carbohydrate reserves in this browse species at various seasonal stages. Thus, the periods could be established when its vigor would be greatest and would be least jeopardized by depletion of food reserves resulting from twig removal and subsequent regeneration of parts. Exploratory phases of the work in central Washington include collection of preliminary samples of tops and roots, preliminary laboratory analyses, and determination of the required number of field samples for the remainder of the work.

Collections and analyses were made for five different size classes of material from the tops of bitterbrush to obtain information on distribution of carbohydrate reserves. As shown in the following tabulation, there is a marked downward gradation in percentage of available carbohydrate, from twigs to heavy stems.

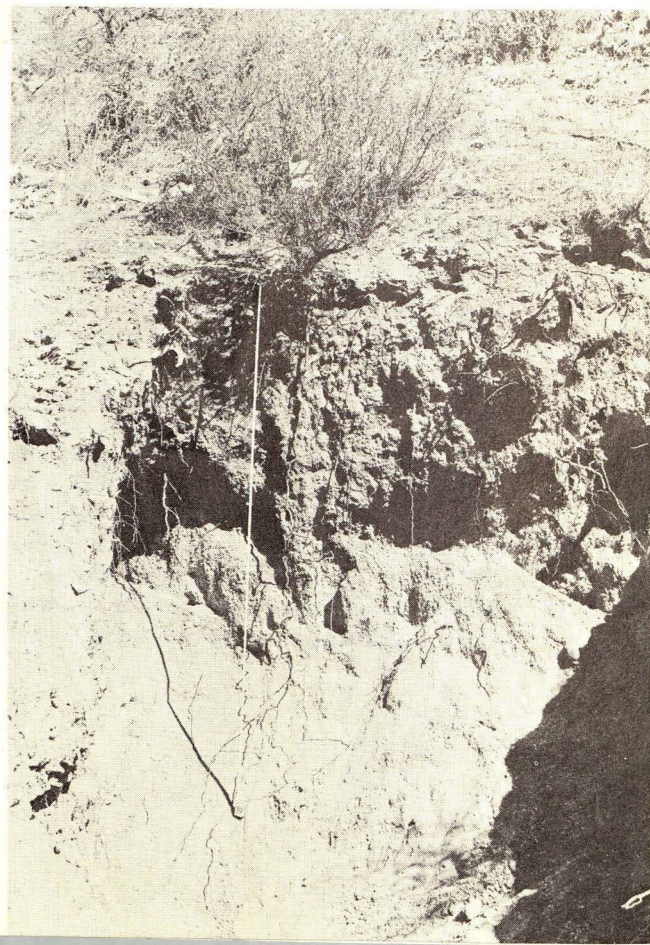
Size class of material (Inch)	Total available carbohydrate (Percent)
0 to 1/4	6.60
Over 1/4 to 1/2	5.55
Over 1/2 to 3/4	4.95
Over 3/4 to 1	4.35
Over 1	3.55

These ratios of available carbohydrate to oven-dry weight of material were used to calculate the amount of carbohydrate in the five size classes of top material for three productive specimens. Because of the large proportion of small twigs and branches, the gradation shown in the tabulation was accentuated. For the specimens studied, it was determined that 62.5 percent of the available carbohydrate of the tops was within the material of 1/2 inch or less in diameter. This demonstrates the importance of the small materials in shrub crowns as food sources and the value of finer stratification among such parts for future analyses.

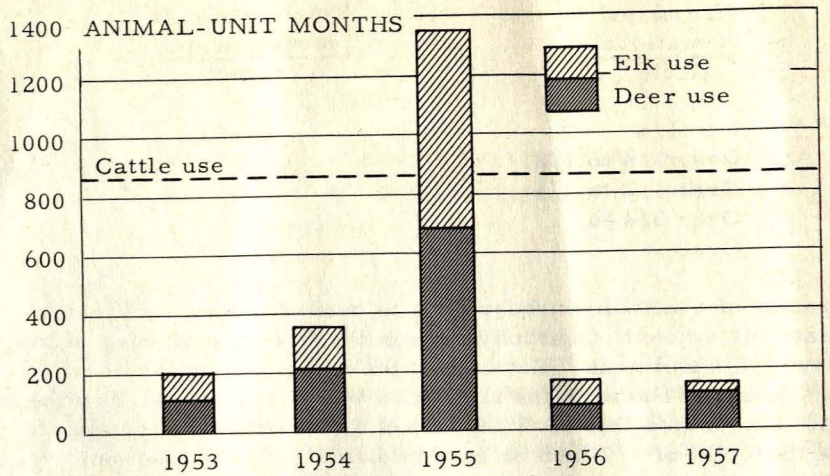
MANAGEMENT OF BIG-GAME RANGES

Forage Utilization by Big Game

Lightest big-game use since 1953 was observed on the Starkey Experimental Forest and Range. Compilations of pellet group counts are now complete for all Starkey range units, and the analysis showed that deer and elk use accounted for only 16 percent of the total animal-unit-months of foraging on the experimental ranges in in 1957. Variations in big-game use between years are great and the period of heaviest use so far has been attributed to an open winter, which permitted game use on



Roots of bitterbrush were excavated to depths in excess of 6 feet to obtain samples for chemical analyses.



Total animal-unit-months of use by deer, elk, and cattle on 12 experimental cattle ranges, Starkey Experimental Forest and Range, 1957.

pastures that cattle use for only 4 summer months. Periods of light game use appear to be associated with less open winters and occasional deviations from the usual migratory route used by elk.

In south-central Oregon, observations on summer use of bitterbrush by deer and cattle have been facilitated by exclosures established 6 years ago. Combined use by the two classes of animals during the summer was found to be 65 percent. However, deer use of bitterbrush inside the cattle exclosures was only 30 percent.

In north-central Washington, a study of competition between deer and livestock for forage on summer cattle ranges was started in cooperation with the Okanogan National Forest. A pair of 2-acre cattle exclosures were established for facilitating determination of herbage use by deer. Only utilization data for the summer were obtained.

Summer deer use was observed on 2 species of grass, 1 sedge, 12 broad-leaved herbs, and 7 shrubs. Deer use of grasses and sedges did not average more than 1.5 percent. Herbs receiving the most use were fireweed, woollyweed, milk-vetch, hawksbeard, lupine, and rose; however, only in the case of woollyweed did deer use exceed 10 percent. Although cattle grazed mainly on grasses, they also used all of the herbs listed above except hawksbeard.

Adaptability of Game Forage Species

Deer range.--Previous plantings of the hardiest grazing-type alfalfas have proved unadapted to site conditions on a mountain deer range in north-central Washington. New trials of different legumes were started by the Mid-Columbia Research Center and the Okanogan National Forest in June 1957. Bramble vetch, birdsfoot trefoil, and common sainfoin were included in the trials and showed excellent germination and emergence. First-season growth of each was superior to the earlier alfalfa plantings. It is too soon to predict how vigorous the stands will become.

Bramble vetch was included in the new trials at 6,000 feet elevation because of its good performance over a 7-year period in the ponderosa pine zone and because it had been less disturbed by pocket gophers than had other legumes.

First-season success of the June plantings again illustrated an advantageous site condition of the northern Cascade Range and Okanogan Highlands. Late spring plantings made in this north-central part of Washington are usually successful, whereas late spring plantings in the southern section usually have little chance of success. The cause may be that the northern mountains have a summer storm frequency and an average summer precipitation that are nearly three times the averages observed at weather stations in the southern part of the State.

Elk range.--An important obstacle to successful reestablishment of grass plantings on high-elevation parks and openings in south-central Washington has been subsurface drainage from remnant snowbanks sheltered during early summer in lodgepole pine and subalpine fir thickets. Of the grasses tried to date, only common timothy has been able to persist--even as a rather poor stand--through the third growing season.

With the help of Wenatchee National Forest personnel, a revised trial was undertaken in late 1957 on this high-elevation elk range. Eight species used this time were selected for their known tolerance of wet soil conditions during the first part of the growing season. Planting was done late enough in the fall to delay germination until spring. To reduce the hazard of soil erosion, standard procedures for seedbed preparation were omitted. Instead, herbicide sprays and use of deep furrow openers on the grass drill were selected as the means for controlling competing annual vegetation.

EFFECTS OF BIG GAME ON TIMBER MANAGEMENT

Elk Browsing

About 5,000 acres of clear-cut patches and burns on the Olympic National Forest are planted each year with Douglas-fir transplants at a cost of $125,000. There is evidence that these large annual investments are jeopardized by browsing elk. A joint study to determine the extent and duration of browsing damage was initiated in 1957 by the Mid-Columbia Research Center, the Puget Sound Research Center, and the Olympic National Forest. Two large elk-proof exclosures and two unfenced areas were established within patch clearcuts on the Quinault Ranger District. Data are being obtained on numbers and heights of young trees, amount and composition of herbaceous and shrub cover, and degree of elk use.

Deer Browsing

According to an exploratory study in central Oregon, two deer repellents, TMTD and ZAC, show promise as a means of reducing deer browsing of ponderosa pine seedlings. Ten percent solutions of these chemicals reduced browsing by 79 and 77 percent, respectively, as compared with no treatment. An adhesive, Rhaplex AC-33 (anacrylin resin emulsion), was mixed with the chemicals. The chemicals had no apparent effect on growth of the seedlings.

PLANS FOR RESEARCH IN 1958

The addition last year of game-habitat research to the range investigation program will continue to require some emphasis on planning. Two new project analyses and several new study plans will be completed. Manuscripts will also be completed on two phases of range and forest relations, one on response of elk sedge to herbage removal, and possibly one on ecology of subalpine range in the Wallowa Mountains. Active projects will be continued. Plans for 1958, by project, are:

1. Management of livestock ranges: Carry out the first reinventory of the second block of Starkey pastures, and continue analysis of data. Complete installation of supplementary loop transects on Starkey pastures.

2. Range condition: (a) Complete analysis of Wallowa subalpine range study. (b) Help the Soil Conservation Service complete a soil survey of the entire Starkey range. (c) Continue studies at all centers of ponderosa pine ranges.

3. Sampling and measurement techniques: Continue testing and modification of the "nested" sampling scheme used by Oregon State College and integrate data with data from the college's projects.

4. Insect-range relations: Continue inventory phases of the insect and shrub study. Also, determine frequency and degree of depredation in relation to plant community characteristics and condition of individual plants.

5. Ecology and physiology: (a) Complete the elk sedge study. (b) Plan for the next phase of the bitterbrush carbohydrate study.

6. Management of big-game ranges: (a) Continue studies in central Oregon and central Washington on forage preferences of deer and intensities of deer use on seasonal ranges. (b) Complete plans and initiate a cooperative study with the Oregon State Game Commission on the relation of deer health and fecundity to range condition. (c) Continue studies of forage species adaptability to deer and elk range on the Okanogan and Wenatchee forests and initiate one new trial on the Snoqualmie National Forest.

7. Grazing and timber production: (a) Continue the study of elk browsing on Douglas-fir. (b) Consider initiation of a formal study of deer repellents. (c) Plan and initiate a study on response of range forage to thinning of overstocked stands of ponderosa pine.

Watershed Management Research

Watershed management research in the Northwest is beginning to occupy an important niche in the total research effort of the experiment station. During the past year the organization expanded considerably, and now includes a total of 6 professional personnel who are investigating watershed problems in 5 separate areas of the Pacific Northwest.

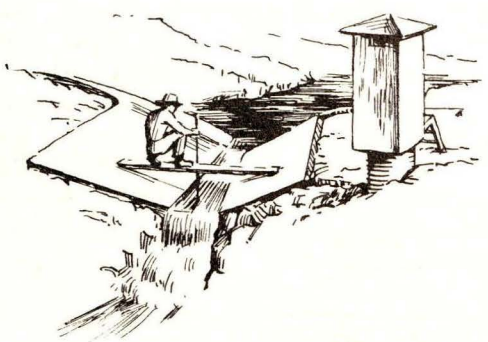
TRAINING

Research personnel must keep abreast of technical developments in their own fields as well as in many related spheres of activity. Normally, each individual furthers his professional competence through in-service training and by his own endeavors. This year, the need for quickly training new personnel demanded increased emphasis on in-service training. Accordingly, the entire staff of the station's watershed management division traveled as a group for 3 weeks to observe firsthand the watershed installations and activities at other western Forest Service experiment stations. Discussions between competent technicians and "on-the-ground" evaluations of many experiments should help avoid many pitfalls and blind alleys of research.

FOREST COVER AND STREAMFLOW

The effect of forest cover on streamflow can be determined from longtime pilot-watershed experiments. Two such experiments in Douglas-fir forests are now in progress: one on the H. J. Andrews Experimental Forest near Blue River in west-central Oregon; the other in the Bull Run drainage, source of Portland's water supply.

These experiments are conducted in six small watersheds whose individual area is less than half a square mile. Streamflow is measured in trapezoidal flumes developed especially for use in mountainous terrain. For greater efficiency in the conduct of these investigations, a residence was built at Blue River and a shelter was erected in the Bull Run watershed.



Trapezoidal flumes such as this are used to measure runoff from 7 gaged watersheds in 3 areas of west-central and western Oregon.

Similar experiments are contemplated for two other areas: the lodgepole pine type of northeastern Oregon, and the mixed conifer type of north-central Washington. A reconnaissance of these two areas has not yet located suitable experimental sites. Additional experiments are needed in other areas with different forest types; these investigations will be undertaken as soon as possible.

FOREST COVER AND PRECIPITATION

Lodgepole Pine

A study in the Blue Mountains of eastern Oregon showed that 24 percent of the winter and early spring precipitation was intercepted by the crowns of lodgepole pine. Although the lodgepole pine stand accumulated less snow than an adjacent meadow, the snow disappeared from both areas at the same time. The daily rate of melt was 0.30 inch in the meadow, and only 0.12 inch in the forest. This experiment pointedly indicates the need for determining the best-sized forest clearing for accumulation and retention of snow.

Douglas-Fir

In west-central Oregon, on the western slopes of the Cascades, a study showed that a stand of Douglas-fir intercepted 24 percent of summer and fall precipitation. The amount of interception varied with storm size, ranging from almost 100 percent for storms with less than 0.1 inch precipitation to less than 20 percent for larger storms.

FOREST COVER, LOGGING, AND EROSION

Normal Erosion

Under virgin Douglas-fir, the normal flow of three streams in the H. J. Andrews Experimental Forest had only three parts per million (ppm) of suspended sediment, but as much as 65 ppm was measured during rapid rise in streamflow. Bedload of these streams, measured in silt basins, averaged only 0.03 acre-feet per square mile per year. This rate of sediment production resulted from an average yearly precipitation of 81.5 inches, of which 80 percent occurred during the 6-month period October through March.

Induced Erosion

In north-central Washington, soil disturbance was measured in two logged areas. The Wyssen Skyline Crane system of logging was used in one, and a ground-skidding tractor operation in the other. Basis of comparison was (1) area and (2) depth of disturbance. Use of the Wyssen system brought about a significant decrease in the amount of mineral soil disturbed, and was equivalent to horse logging in its effects. Comparison of the Wyssen system with the tractor operation shows the following results:

	Mineral soil disturbance--Percentage of area		
	(Shallow)[1/]	(Deep)[2/]	(Total)
Wyssen	2.2	3.2	5.4
Tractor	6.3	15.9	22.2

1/ Less than 1 inch.
2/ More than 1 inch.

In southwestern Oregon, 35 clear-cut areas were studied to evaluate sources of erosion. The areas were classified by three methods of skidding, and the most important source of erosion was determined for each area. The following tabulation shows that roads were among the 3 important sources of erosion on 33 areas, and were the most important source on 18 areas.

	Tractor	High lead	Tractor and high lead	Total
Roads	7	8	3	18
Poor application and choice of logging method	7	-	3	10
Disturbed water channels	2	4	1	7
TOTAL	16	12	7	35

Erosion From Skid Trails

Erosion from skid trails is being studied on a logging operation on the Starkey Experimental Forest and Range in the Blue Mountains. Shortly after logging was completed in one section of the operation, metal troughs were installed on three pairs of skid trails of varying length and gradient. The troughs intercept surface flow, and conduct the water and sediments into storage tanks. One skid trail of each pair was seeded in the fall of 1957 with a mixture of hard fescue, timothy, and orchardgrass. This treatment is designed to test the effectiveness of seeding in reducing erosion from skid trails.

RESEARCH METHODS

Soil Stability

A modification of the standard wet-sieving method is being used to analyze aggregate stability of some important soils in central Washington. Average size of soil aggregates is used to characterize soil erodibility, a larger value indicating a more stable soil. Field observations tend to confirm laboratory ratings. Thus, the aggregate size of the highly erodible Mission Creek fine sand is only 0.85 mm, while that of the more stable Entiat River loamy fine gravel is 2.99 mm. Surface or A horizons in two other soils studied were found to have aggregates significantly larger in size than those measured in the underlying B horizons. These tests are part of a series of laboratory determinations being made to determine the characteristics that relate to erodibility of soils on the east slope of the Cascade Range.

Soil Erosion

A portable device was developed to measure soil erosion following logging and road building. This fall it is being tested in two separate areas in southwestern Oregon. Roof flashing delineates a plot, and a length of rain trough channels the run-off into a 55-gallon drum, where most of the heavy solids are deposited. Each time this drum is filled, half its contents is automatically siphoned out through a flow divider. Part of this discharge empties into a second storage drum, and the remainder is wasted to the ground. A wide range in capacity can be obtained by varying the sizes of the discharge orifices of the flow divider. A combination of 1/4 and 3/4 inch orifices can handle approximately 440 gallons between servicing visits. In 15 trial runs, the average discharge from the smaller orifice was 14.2 percent of the total discharge.

Precipitation

A large precipitation storage gage being used in one remote site has been equipped with a device for quick readings. The quantity of stored precipitation is determined by measuring the height of the liquid in a vertical plastic tube attached by pipes to the center of the gage. This manometric device eliminates the need for a direct measurement of water depth in the gage itself. The storage gage was calibrated before it was installed.

PLANS FOR WATERSHED MANAGEMENT RESEARCH IN 1958

Experimental Watersheds

Collection of streamflow and sediment data will be continued on the H. J. Andrews Experimental Forest and in the Bull Run watershed. Treatment of one of the test watersheds at H. J. Andrews Experimental Forest will begin with the construction of roads for logging. A reconnaissance for additional watershed study sites will be made in western and northeastern Oregon and in central Washington.

Runoff and Erosion

The effects of cattle grazing on erosion will continue to be measured on the Starkey Experimental Forest and Range, and studies of methods for controlling surface runoff and erosion from logged areas will be expanded in the Blue Mountains and in southwestern Oregon.

Additional tests are planned to determine erodibility of soils in central and north-central Washington. Similar determinations are scheduled for soils in the Bull Run watershed.

Precipitation and Interception

Additional areas in the Blue Mountains have been selected for further study of snow accumulation and melt in lodgepole pine forests. A second season of measurements will be needed to strengthen data on interception of precipitation by Douglas-fir at the H. J. Andrews Experimental Forest.

Forest Disease Research

About 40 diseases are injurious enough in forests of Oregon and Washington to require consideration in the station's program, but only a few can be studied effectively at one time with the manpower now available. As a guide to concentration of research efforts where they are most urgently needed, an analysis of the forest disease problem in the Pacific Northwest was made during the past year. Need for study of each disease was evaluated on the basis of value of host, severity of damage, probable usefulness of results, time required to obtain results, availability of specially qualified investigators, and present or probable availability of information from other sources.

On these bases, high research priorities have been assigned to root rots of Douglas-fir and ponderosa pine, dwarfmistletoes on ponderosa pine and Douglas-fir, decay of killed timber, ponderosa pine needle blight, diseases of Douglas-fir and ponderosa pine reproduction, heart rots of true firs and young-growth Douglas-fir, and white pine blister rust. Although other diseases cannot be ignored, most of the station's work during the next few years will be on these outstandingly important problems.

NURSERY AND PLANTATION DISEASES

Although reasonably satisfactory control of damping-off at the Wind River Nursery has been attained by the addition of sawdust to acidified soil, search continues for better methods. The addition of sawdust, even though accompanied by nitrogen addition, caused chlorosis of 2-0 Douglas-fir seedlings. Subsequent application of nitrogen, necessarily light to avoid stimulation of fall growth, failed to correct the chlorosis. Seedbeds with sawdust as a soil amendment had higher surface soil temperatures than those without sawdust and also required more water to maintain adequate soil moisture and reduce soil temperatures.

Addition of sawdust to acidified soil at the Bend Nursery continued to give good control of late root rot caused by Fusarium. Late root rot at this ponderosa pine nursery has also been reduced by fall-sowing seed. The best seedling stands were obtained from seed fall-sown at a depth of 3/8-inch. Sowing at this depth retards emergence enough to minimize frost damage but not enough to result in heavy loss from either pre-emergence damping-off or late root rot.

A preliminary test indicated that even short periods of heeling-in reduce survival of field-planted 2-0 ponderosa pine. Further tests will be made of the effect of handling practices on survival of planted stock.

ROOT DISEASES

Poria Root Rot of Douglas-fir and Other Conifers

The known range of Poria weirii was extended to include the upper Rogue River drainage in southwestern Oregon and several localities east of the Cascade Range in

both Oregon and Washington. Douglas-fir and grand fir were the species most frequently affected, but larch and ponderosa pine in mixed stands were also killed. This root rot is probably common, and at least locally damaging, in Douglas-fir and true fir types throughout the region, but is of little or no importance in predominantly pine types. Extension of its known range is not a result of recent spread; this disease has simply been overlooked in many places before because too little attention has been given to some of the forest types in which it occurs.

Armillaria Damage to Ponderosa Pine Reproduction

Armillaria mellea attacks trees of all species and size classes and often kills crop trees or even destroys all the reproduction over small areas. A damage survey, cooperative with J. Neils Lumber Co., yielded the following data from 201 1/100-acre plots distributed over 850 acres in a residual pine stand:

Number of plots with reproduction either living or dead	171
Percentage with one or more trees killed by A. mellea	25
Percentage with all trees killed by A. mellea	2
Percentage with crop trees killed by A. mellea	5

Killing has been occurring here at an approximately constant rate for at least a decade and shows no signs of abating. Some of the deforested patches are already about 1/5 acre in extent and are growing larger as additional trees are killed around their edges.

Phytophthora Root Disease of Port-Orford-cedar

This disease was found to have spread about 5 miles up both Elk River (northwestern Curry County) and the Middle Fork of the Coquille River. Near McGribble Guard Station, in the northwestern part of the Siskiyou National Forest, it was found for the first time in natural stands well above the river bottoms and away from the low coastal shelf. Like many other new infection centers, this latter area is associated with road work.

STEM DISEASES

Dwarfmistletoe on Ponderosa Pine

Even where dwarfmistletoe is abundant on ponderosa pine, many healthy seedlings and saplings are usually present. The following data, obtained from 1- and 2-milacre quadrats in moderately to very severely infected parts of 3 stands, are illustrative of a condition that has been observed throughout the region:

	Pole Creek	Pringle Falls	Round Mountain
Number of quadrats	370	349	120
Percentage stocked (all trees)	75	72	79
Percentage stocked (healthy trees):			
More than 6 inches tall	58	62	72
More than 4 feet tall	24	38	51

Since infection is much more common in large reproduction than in small, most of the large reproduction must be sacrificed if all infected trees are to be eliminated from the stand. Nevertheless, it is evident that complete sanitation will ordinarily be possible without reduction of stocking below a reasonably adequate level.

Dwarfmistletoe on Douglas-fir

This parasite is destructive east of the Cascade Range and in southwestern Oregon. Damage appears to have been unusually severe in the latter area during recent years. Mortality has resulted in heavy volume losses, which are continuing in many old-growth stands that would otherwise be expected to persist for 50 years or more. Problem areas are easily recognizable from the air; they probably are also recognizable from aerial photos at a 1:12,000 or larger scale. Little is known about this disease, and salvage is the only method now available for reducing losses

White Pine Blister Rust

Extent of blister rust mycelium beyond visible canker limits on sugar pine was found to be greater in the spring than in late summer. Even in the spring, however, this extent is rarely greater than 4 inches. These results indicate that pruning of infected branches will almost always prevent further spread of the cankers if cuts are made 6 inches or more below visible discoloration in the spring or 3 inches or more in late summer.

Trunk Rust of Ponderosa and Lodgepole Pines

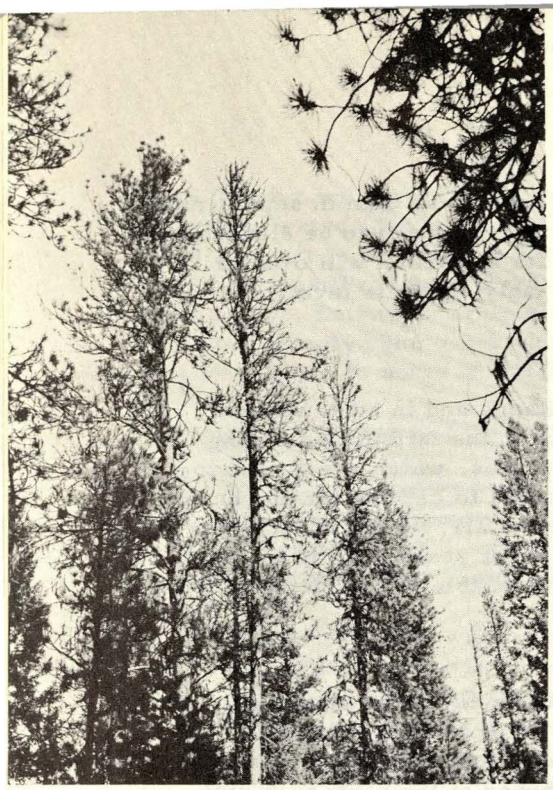
A native rust, long known in this region but formerly considered of little importance, is the suspected cause of widespread killing of tops and sometimes of entire trees in one locality, and of appreciable but somewhat less severe damage at several other places. This rust may have become more abundant during recent years, but it is more probable that the effects of the disease have previously been overlooked or confused with those of other injurious agents.

Elytroderma Needle Blight of Ponderosa Pine

Needle blight again increased to a small extent in the Deschutes and Klamath drainages of Oregon and in northern Washington. Damage is still slight in these localities. Elsewhere in the region, this disease has remained at about the same level as in 1956, or has declined in severity.

Heavy mortality has occurred in several residual stands soon after partial cutting for salvage of blighted trees. Blight does not appear to be entirely responsible, but its weakening effects probably hasten and increase the damage. These observations suggest that partial cuts are undesirable where blight is severe. Logging in badly blighted stands should be restricted to clear cutting in the worst centers of infection, with the remainder of the stand left undisturbed.

Inadequate knowledge of the parasite's life cycle, and especially of the conditions governing infection, has interfered with efforts to reduce losses. To remedy this situation, the station is cooperating with Oregon State College in basic research on the blight fungus.



Ponderosa pine crowns thinned by severe needle blight infection.

Needle Diseases of Larch and Lodgepole Pine

Needle blight of larch was unusually abundant and conspicuous in 1957 throughout the range of its host. This disease is often confused with frost injury. It is a near relative of ponderosa pine needle blight but is much less injurious.

Killing of lodgepole pine foliage, by a fungus not yet definitely identified, was common in several localities in eastern Oregon in 1956 and was appreciably more severe in 1957. Current damage consists entirely of reduction in growth rate, but some killing of trees will probably occur within the next year or so if the disease continues at its present level. The causal fungus is believed to be one that has been known in this region for more than 30 years but that has previously been found only on occasional trees.

DECAYS AND STAINS OF FOREST PRODUCTS

On-the-job Treating Tests

Decay is now well established, after 4 years' exposure, in flooring units of treated and untreated ponderosa and southern pine sapwood and untreated mill-run white fir. Treated mill-run white fir is still free from decay. No difference is yet apparent in the relative effectiveness of the various dip treatments.

PLANS FOR FOREST DISEASE RESEARCH IN 1958

1. Develop cheaper and more effective methods for control of nursery diseases. Give further attention to the effects of shipping and storing practices on survival in plantations.

2. Examine all Poria root rot plots and start work on a progress report for publication in 1960; get additional information on ecological relations of this root rot and on survival of western hemlock in infection centers.

3. Make additional surveys of Armillaria damage to ponderosa pine reproduction and establish plots for determination of long-term effects of this disease.

4. Continue studies of distribution, effects, and control of dwarfmistletoe in ponderosa pine stands.

5. Cooperate in survey of damage by dwarfmistletoe to Douglas-fir on the Rogue River National Forest.

6. Identify the fungus causing top-killing of mature ponderosa pine; get additional information on distribution of this disease, and determine approximate extent of damage in affected stands.

7. Continue studies of deterioration rates in beetle-killed and windthrown timber.

AERIAL SURVEY TECHNIQUES

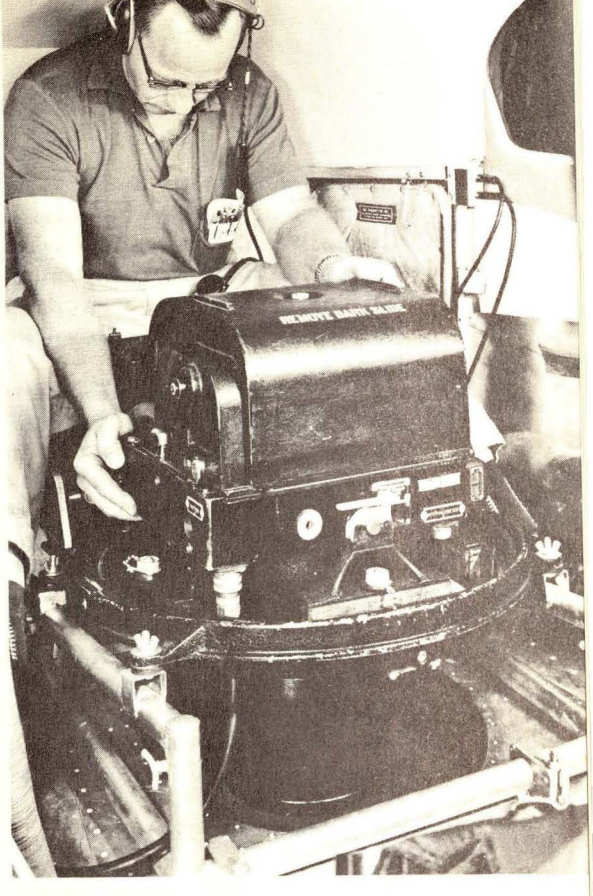
The aerial survey techniques research project is sponsored by the station's forest economics and forest insect research divisions and the timber management division of the regional office. In the field of forest insect surveys, studies in 1957 were aimed at improving the accuracy with which current ponderosa pine mortality can be recognized on aerial photos. Also, aerial survey techniques were tested on the balsam wooly aphid infestation in southern Washington. In the field of forest inventory surveys, tests were made to determine the effect of photo scale on accuracy of tree height measurement and species identification. A start was made on a study to improve type maps for forest management purposes.

Equipment

During the spring of 1957, the aerial-survey techniques project made substantial additions and improvements in its equipment. Acquisition of a new airplane, a Cessna 180, should greatly increase efficiency in making aerial techniques studies. Cruising speed, rate of climb, and service ceiling of the new plane are greater than those of the one formerly used. Consequently, the progress of photographic missions will be accelerated and the range of photo scales increased. A new type of camera mount was designed and built to accommodate several different aerial cameras and to adjust for either vertical or oblique photography.

An aerial camera with shutter speeds to 1/900 second was acquired to test the effect of fast shutter speeds on photo image quality. The problem of efficient interpretation of aerial color transparencies was solved by purchasing a scanning stereoscope.

New Cessna 180 provides a most efficient tool for aerial techniques research.



Aerial camera arrangement in Cessna 180. Tubular frame unit is shifted laterally for oblique photography.

Insect Damage Evaluation

Bark beetles -- The separation of current ponderosa pine mortality from older mortality is difficult in those areas where dead foliage remains on the trees for several years. A study was made to determine if this separation could be made more accurately by comparing two sets of photos taken a year apart (sequential photography) than by interpreting photos from a single flight.

For this particular test there was no difference in interpretation accuracy between the two techniques. Apparently the dead trees on the test area lost most of their needles within a year after death so that it was possible to distinguish current from older mortality on a single set of photos. Sequential photography should be of value in other areas where the dead foliage remains on the trees for several years. Further tests of this technique need to be made.

Panchromatic film was substantially inferior to both color and camouflage-detection films with either technique. This result differs from that of a previous study, which had showed no significant difference between films.

Another major photo interpretation error in assessing ponderosa pine mortality has been failure to distinguish between trees that are dead and those that are merely top-killed. An exploratory study was started to see if aerial photos taken slightly off the vertical would decrease this type of interpretation error. A special camera inclinometer and preliminary pilot-sighting device were constructed to enable photographs to be taken of specific target areas at various oblique angles. An angle of about 20^{o} from the vertical appears to be best for distinguishing top-kills.

Balsam woolly aphid. --Aerial photographic appraisal of damage caused by the balsam woolly aphid was given a full-scale test on 400,000 acres around Mount St. Helens, Wash. Major landowners, both public and private, cooperated to obtain an estimate of the amount of timber killed and damaged by this insect, currently the most destructive in the Pacific Northwest. Large-scale color photos were used to supplant much of the field work that would otherwise have been required.

Photography, photo interpretation, and field work have been completed and a preliminary analysis of the data has been made. Results indicate that on color photographs at a scale of 1:4,000 an interpreter can successfully identify the true firs and separate out those that are dead and those that are heavily damaged. The volume of dead and damaged true firs was estimated on 160 photo plots, of which 50 were checked in the field. To obtain the final volume estimate, data from the photo plots were adjusted by using the field plots in a regression-sampling scheme. An estimate of equal accuracy based on field work alone would require about 175 field plots.

The color film used on this project was deliberately underexposed by 50 percent in order to use a faster shutter speed and obtain sharper pictures. Special processing procedures were used to compensate for this underexposure. The resulting color transparencies were sharp, clear and well balanced, the best yet taken for aerial techniques studies at this station.

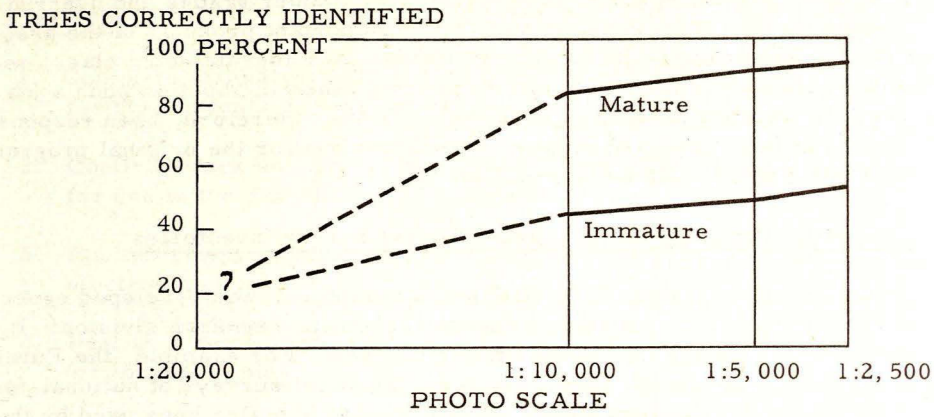
Forest Inventory Techniques

Large-scale aerial photos. --The second phase of a study to determine the effect of photo scale on the accuracy of forestry measurements was completed and reported on at the annual meeting of the American Society of Photogrammetry in March. This phase dealt with the accuracy of tree height measurements and species identification on both color and panchromatic films at scales ranging from 1:20,000 to 1:2,500.

The accuracy of species identification was found to increase significantly as photo scale increased. At all scales, the accuracy was substantially greater for mature stands than for immature stands. The effect of photo scale on the accuracy of tree height measurement was obscured by the fact that individual interpreters obtained different results. The type of film had no effect on the accuracy of either tree height measurement or species identification.

Forest management type map specifications. -- Preliminary work was started on a study to improve forest type maps used for resource management on the national forests. Questionnaires were sent to each ranger district and supervisor's office in Region 6 in order to find out what kind of information was desired on such a type map. Replies indicated that a majority favored the use of 10-acre type minimums, designation of secondary species in all types, indication of two-storied stands, and density classes for mature as well as immature types. Many also feel that stereograms of principal forest types would materially aid the process of type mapping. Opinion was divided on the desirability of including information on overstocked areas, site class, soil characteristics, brush density, logging operability, and "in-place" volume estimates.

Visual aerial checking of timber types. --About 12 hours of flying time were spent by forest survey field men in testing the possibility of using visual aerial observation to improve type maps in remote areas. It was concluded that visual observations are much more positive than photo interpretation for identifying tree species and that the method provides the only practical way for improving forest type maps in remote areas.



Effect of photo scale on accuracy of species identification. Results are average for three interpreters on both panchromatic and color film. No data were obtained from the 1:20,000-scale photos because it was impossible to locate the test trees on them. After inspecting the test area, the interpreters estimated that about 20 percent of the trees were identifiable at this scale.

Plans for 1958

Research work on aerial survey techniques will place major emphasis on forest inventory problems in 1958. Of first priority will be studies to develop improved aerial-photo volume tables and methods of application. Techniques developed by these studies will be useful to forest surveys, forest insect surveys, and timber management inventories. A study will also be started to determine the value of aerial photos for obtaining forest site-class information.

Studies will be continued in an effort to (1) improve recognition of insect-caused damage and mortality and (2) develop better type maps for forest resource managers.

STATISTICAL TECHNIQUES

At various times in the station's history, a small statistical section has been available to all research divisions for analyzing data from projects. In recent years this section has expanded until it now has four members. Its function has also expanded to include counseling on statistical methods and research in statistical techniques. Four of the accomplishments in statistical techniques research in 1957 are listed below.

Electronic Computer Program for Mill Scale Studies

An analysis program for mill-scale study data, originally developed in 1956, was modified and improved in 1957. This new program, designed for IBM's Type 650 electronic computer, was used repeatedly during the year by the station's forest utilization research division and by national-forest administration in Missoula, Mont. Other agencies are planning to use the program in 1958.

This program calculates board-foot volumes by lumber grades and overrun percentages for each log in a mill-scale study. More important products of the program are average board-foot volumes by lumber grade for each log-diameter class, within log grades and within species. The program accomplishes in about an hour a job that previously required months of tedious handwork. It has, therefore, been responsible for a large saving in both time and money. Specifications for the original program were published October 1956 as Research Note No. 133.

Electronic Computer Program for Extensive Forest Survey Inventories

This program, also designed for IBM's 650 computer, was developed especially for forest survey work in the station's forest economics research division. It can, however, be adapted for other extensive timber cruises. For example, the Forest Service is using this program for large-scale management surveys of national-forest working circles in the Pacific Northwest. The program has also been used by the Bureau of Indian Affairs in eastern Washington and by Pilot Rock Lumber Co. for a survey of its holdings in eastern Oregon.

About 6,000 trees are processed per hour under the program. This includes calculations of cubic- and board-foot volumes for each tree. Complete summaries of information are provided for each field plot, for each species (all plots combined), and for each sampling stratum. This includes a stand table and a stock table for each species.

Technique for Calculating Cubic Volumes in Butt Logs

Calculations of cubic-foot volumes for butt logs are often required for tree volume tables and for other purposes. These calculations are complicated by a unique taper condition in the butt log. A fast and accurate technique for accomplishing this job was developed in the statistical section. It was described and illustrated in the Journal of Forestry for September 1957.

Tree Volume Constants for 32-foot Log Scaling Length

A table of tree volumes (board-feet) based on total height, d.b.h., Girard form class, and a 16-foot log scaling length was published several years ago by Mason, Bruce, and Girard, a Portland firm of consulting foresters. A need has since arisen for comparable information based on a 32-foot log scaling length. To meet this need, a table of volume constants was developed for the following formula:

$$V = a + bH$$

where V = tree volume in board-feet (Scribner)--logs scaled in 32-foot lengths.

H = total tree height in feet.

A set of "a" and "b" constants is available for each form class from 60 to 90 and for each diameter outside bark at breast height from 11.0 to 99.9 inches.

Only two copies of the table were made since they are somewhat bulky. If additional copies are needed they can be reproduced.

Plans for 1958

1. Complete an analysis procedure for electronic computation of growth data for the station's Forest Survey inventory program.

2. Continue work on an integrated set of form class cubic-foot volume tables for use in the Forest Survey program.

3. Publish specifications for processing Forest Survey inventory data on an electronic computer.

4. Publish 4 new volume tables: 2 for red alder, 1 for Sitka spruce, and 1 for lodgepole pine.

1957 Publications
by members of the staff and cooperators

FOREST ECONOMICS

Division of Forest Economics Research
Forest resources and forest industries of Lane County, Oregon. Pacific Northwest Forest and Range Expt. Sta. Forest Survey Rpt. 131, 117 pp., illus.

A comprehensive report presenting results of a Forest Survey reinventory of the county's forests, correlated with findings of several special studies on the organization and character of the county's forest industries. Included is information on consumption of raw material and production of forest products by the forest industries.

McMahon, R. D.
Lodgepole pine forsakes Cinderella role. Timberman 58(11):34-38, illus.

A weed species a few years ago, lodgepole pine is the subject of rapidly increasing interest. Economic incentives, provided by growing markets for lumber and pulpwood, are prompting a second look at this species. This article highlights lodgepole pine resources in the West in general and in the Pacific Northwest in particular, and it discusses economic and physical factors that govern the use of the species.

Spada, B., and Bones, J. T.
Forest statistics for Snohomish County, Washington. Pacific Northwest Forest and Range Expt. Sta. Forest Survey Rpt. 128, 30pp., illus.

A statistical report presenting results of a recent reinventory of the county's forests. Contains information about land classification, forest-land area and ownership, and timber volumes and utilization. Some descriptive and interpretative information is included.

Twerdal, M. P., and MacLean, C. D.
Forest statistics for Tillamook County, Oregon. Pacific Northwest Forest and Range Expt. Sta. Forest Survey Rpt. 130, 34 pp., illus.

A statistical report presenting results of a recent reinventory of the county's forests. Contains information about forest-land area and ownership, land classification, and timber volumes and utilization. Some descriptive and interpretative information is included.

Usher, J. H., and Hall, H. H.
Forest statistics for Lincoln County, Oregon. Pacific Northwest Forest and Range Expt. Sta. Forest Survey Rpt. 129, 30 pp., illus.

A statistical report presenting results of a recent reinventory of the county's forests. Contains information about land classification, forest-land area and ownership, and timber volumes and utilization. Some descriptive and interpretative information is included.

FOREST MANAGEMENT AND SILVICULTURE

Carow, John, and Ruth, Robert H.
Mobile yarder shows promise in salvage. Timberman 58(10):66-69, 104, and 108; illus.

The idea of using a mobile high-lead yarder for salvage operations in old-growth Douglas-fir leave settings was tested on the H. J. Andrews Experimental Forest. The method was shown to be practical from the standpoint of logging costs, and logging damage to the residual stand was held within reasonable limits.

_____ and Silen, Roy R.
Using the staggered setting system, what are logging costs? Timberman 58(4):48-53, illus.

Based on experience in logging 900 acres of old-growth Douglas-fir on the H. J. Andrews Experimental Forest, this article presents costs of logging as related to size of clearcut, yarding method, yarding distance, slope, and amount of road construction.

Dimock, Edward J. II
A comparison of two rodent repellents in broadcast seeding Douglas-fir. Pacific Northwest Forest and Range Expt. Sta., Res. Paper 20, 17 pp., illus.

An account of a replicated test to show merits of endrin and tetramine rodent repellents in treating Douglas-fir seed for artificial reforestation by broadcast seeding.

Dyrness, C. T., Youngberg, C. T., and Ruth, Robert H.
Some effects of logging and slash burning on physical soil properties in the Corvallis watershed. Pacific Northwest Forest and Range Expt. Sta. Res. Paper 19, 15 pp., illus.

Physical properties of soil in undisturbed, disturbed-unburned, and lightly burned parts of clearcuts remained closely similar to those under adjacent timber stands. Only on the severely burned part (8 percent of the area) was the surface soil seriously affected.

Hayes, G. L., and Stein, W. I.
Eliminating blister rust canker from sugar pine by pruning. Pacific Northwest Forest and Range Expt. Sta. Res. Note 151, 8 pp., illus.

In southwestern Oregon, sugar pine is often the fastest growing component of the advance reproduction, but is frequently infected with blister rust. A survey on the South Umpqua Experimental Forest in 1952 indicated that the number of sugar pine crop trees could probably be increased by removing cankered branches. Two subsequent projects demonstrated that such pruning is feasible.

Morris, W. G., Silen, R. R., and Irgens-Moller, H.
Consistency of bud bursting in Douglas-fir. Jour. Forestry 55:208-210, illus.

When trees from 13 different localities in western Oregon and western Washington were planted together in 3 widely different plantations, trees from some sources consistently burst their buds earlier than those from other sources. Similarly, some naturally grown trees always burst their buds ahead of other nearby trees.

Mowat, Edwin L., and Silen, Roy R.
A test of grafting ponderosa pine. Pacific Northwest Forest and Range Expt. Sta. Res. Note 155, 5 pp. illus.

With either dormant or succulent material, cleft grafting proved best of five methods tested at the Bend Nursery for field use in the dry hot climate of eastern Oregon.

Ruth, Robert H.
Ten-year history of an Oregon coastal plantation. Pacific Northwest Forest and Range Expt. Sta. Res. Paper 21, 15 pp., illus.

After 10 years, the stocking of planted conifers was good (581 trees per acre). Most significant was the finding that stand establishment could have been obtained more economically if different regeneration treatments had been applied to different parts of the 4-acre study area.

Staebler, George R.
Early effect of two successive thinnings in western hemlock. Pacific Northwest Forest and Range Expt. Sta. Res. Note 146, 8 pp., illus.

Increment and other stand data are presented for three compartments in a commercial thinning experiment on the Hemlock Experimental Forest. Low- and crown-thinned stands (3-year cycle) are compared with an unthinned check stand.

Design for a test of commercial thinning on the Hemlock Experimental Forest in western Washington. Jour. Forestry 55:810-814, illus.

Describes problems and layout in designing an experiment to test economic and silvical aspects of a commercial thinning in young-growth western hemlock.

Stein, William, I.

A successful direct seeding of sugar pine. Pacific Northwest Forest and Range Expt. Sta. Research Paper 25, 19 pp., illus.

In southwestern Oregon, the first pilot-scale direct seeding of sugar pine produced a well-stocked stand of seedlings on a 45-acre tract. Methods used are described, and leads for improving seedspotting are given.

Tarrant, Robert F.

1956 bibliography of Pacific Northwest forest soils publications. Pacific Northwest Forest and Range Expt. Sta. Res. Note 135, 2 pp.

Compilation of forest soils research publications for the Pacific Northwest during calendar year 1956.

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Soil moisture conditions after chemically killing manzanita brush in central Oregon. Pacific Northwest Forest and Range Expt. Sta. Res. Note 156, 4 pp., illus.

Killing manzanita brush with chemicals greatly reduced soil moisture loss during the summer drought. The amount of moisture saved was about the same, whether dead brush was removed or left standing.

Trappe, James M.

Experience with basal area estimation by prisms in lodgepole pine. Pacific Northwest Forest and Range Expt. Sta. Res. Note 145, 6 pp., illus.

To estimate basal area in lodgepole pine stands within allowable limits of error, more samples are required when using a 4-diopter prism than when measuring d.b.h. on 1/20th-acre plots.

_____

Some probable mycorrhizal associations in the Pacific Northwest. Northwest Sci. 31(4):183-185.

Associations with specific mycorrhizal fungi are reported for Douglas-fir, ponderosa pine, western larch, lodgepole pine, grand fir, and quaking aspen.

Worthington, Norman P.

Some economic considerations in thinning Douglas-fir. Pacific Northwest Forest and Range Expt. Sta. Res. Note 137, 8 pp.

Describes an 8-year record of light, frequent thinnings made annually in 55-year-old Douglas-fir on the McCleary Experimental Forest.

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Skidding with horses to thin young stands in western Washington. Pacific Northwest Forest and Range Expt. Sta. Res. Note 138, 6pp. illus.

Costs of horse-skidding pulpwood and sawtimber are analyzed for young-growth thinning operations in the Puget Sound area.

Worthington, Norman P.
Silvical characteristics of red alder. Pacific Northwest Forest and Range Expt. Sta. Silvical Ser. No. 1, 15 pp., illus.

Discusses existing silvical knowledge of red alder.

FOREST PROTECTION

DISEASE

Hunt, John, and Childs, T. W.
Ponderosa pine needle blight in eastern Oregon during 1955 and 1956. Pacific Northwest Forest and Range Expt. Sta. Res. Note 147, 9 pp., illus.

Briefly describes behavior and distribution of the disease. Average infection intensity on 54 plots was the same in both years.

_____ and Dimock, Edward J. II
Port-Orford-cedar--a poor risk for reforestation. Pacific Northwest Forest and Range Expt Sta. Res. Note 139, 3 pp.

Susceptibility to unseasonably cold weather and to a killing root disease makes this species undesirable for forest plantings.

_____ and Wright, Ernest
Needle cast of Sitka spruce in Oregon. Plant Dis. Rptr. 41:650

Describes needle cast previously unreported in this region.

Wright, Ernest
Importance of mycorrhizae to ponderosa pine seedlings. Forest Science 3:275-280, illus.

In a planting on a good site, non-mycorrhizal nursery stock was smaller and gave poorer survival than mycorrhizal stock.

_____
Cytospora canker of Rocky Mountain Douglas-fir. Plant Dis. Rptr. 41:811-813, illus.

Cytospora is a secondary disease that commonly infects weakened conifers.

_____
Cytospora cankers of cottonwood. Plant Dis. Rptr. 41:892-893, illus.

The fungus is not a virulent parasite but is a disease of low-vigor trees.

_____
Influence of temperature and moisture on damping-off of American and Siberian elm, black locust, and desertwillow. Phytopath. 47:658-662, illus.

Gives results of tests made under controlled conditions. Growth rates of the damping-off fungi in culture showed no consistent relation to damage caused in nursery beds.

Wright, Ernest, and Tarrant, Robert F.
Microbiological soil properties after logging and slash burning. Pacific Northwest Forest and Range Expt. Sta. Res. Note 157, 5 pp.

Bacteria and actinomycetes were more numerous, and fungi were less numerous, in severely burned than in unburned soils.

FIRE

Cramer, Owen P.
Test of wind predictions for peak fire-danger stations in Oregon and Washington. Pacific Northwest Forest and Range Expt. Sta. Res. Paper 22, 41 pp., illus.

Relative accuracy of several wind-speed forecasting methods was tested during the forest fire seasons of 1950 and 1951. Accuracy of methods tested varied significantly between stations and no one method was best for all stations.

_____
Frequency of dry east winds over northwest Oregon and southwest Washington. Pacific Northwest Forest and Range Expt. Sta. Res. Paper 24, 19 pp., illus.

East-wind frequencies vary by month, and the pattern of monthly variation differs with elevation. Following August, with its near minimum frequencies at all elevations, September bears the greatest impact of easterly winds as they affect forest fire control.

_____
Forest fire weather in western Oregon and western Washington in 1957. Pacific Northwest Forest and Range Expt. Sta. Res. Note 154, 9 pp.

Severity of fire weather was near normal during the April-October fire season. In western Oregon, the season was slightly more severe than in 1956; in western Washington, the season was about as severe as in 1956.

INSECTS

Buckhorn, W. J.
Forest insect conditions, Malheur National Forest and adjacent timberlands, 1946-1956. 12 pp., illus. Pacific Northwest Forest and Range Expt. Sta.

Summary of the principal forest insect infestations over a period of 11 years.

_____ and Lauterbach, P. G.
Timing of aerial surveys for the balsam woolly aphid. Pacific Northwest Forest and Range Expt. Sta. Res. Note 142, 2 pp.

Aerial flights were made at 25-day intervals to determine the period when foliage discoloration caused by this insect becomes most conspicuous.

Furniss, R. L., and Every, R. W.
Carpenter ant control. Oregon State Col. Ext. Cir. 627, 5 pp., illus.

A summary of the latest information on preventing and controlling damage by this insect.

Johnson, N. E., and Wright, K. H.
The balsam woolly aphid problem in Oregon and Washington. Pacific Northwest Forest and Range Expt. Sta. Res. Paper 18, 34 pp., illus.

Data are presented on the extent of the current outbreak, characteristics of the insect, and the efficacy of various types of control. The problem is being attacked through surveys, salvage, and research. Recommendations are made as to means and methods for achieving greater progress in controlling this insect.

Pope, R. B.
The role of aerial photography in the current balsam woolly aphid outbreak. Forestry Chron. 33:263-264.

During the current outbreak of the balsam woolly aphid in the Pacific Northwest, aerial photos are being used by land managers to help determine the location, extent, and trend of damage. Studies are being conducted to develop methods for making greater use of aerial photos to collect such data more accurately, faster, and at less cost.

Thomas, G. M.
Climate and growth rate as related to an outbreak of silver fir beetles. Pacific Northwest Forest and Range Expt. Sta. Res. Note 150, 5 pp., illus.

Although abnormal weather conditions prevailed before and during the beetle outbreak, no correlation could be found between climate (temperature and humidity combined) and vigor as expressed by radial growth.

Whiteside, J. M.
Forest insect conditions in the Pacific Northwest, 1956. 40 pp., illus. Pacific Northwest Forest and Range Expt. Sta.

Detailed summary of the principal forest insect infestations during the year, showing acreage damaged and intensity of damage by each insect species for forested areas (national forest or Bureau of Land Management district).

Important forest insect outbreaks in Oregon and Washington in 1957. 6 pp. Pacific Northwest Forest and Range Expt. Sta.

Summary of the principal forest insect infestations in the region during 1957.

Wright, K. H., and Johnson, N. E.
Chermes threaten Northwest white fir forest. Timberman 58(7):82-84, illus.

Information is given on habits and characteristics of this imported insect pest to aid the forester in recognizing the insect and its damage.

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FOREST PRODUCTS UTILIZATION

Clarke, E. H. and Knauss, A. C.
Veneer recovery from peeler grade Douglas-fir logs--southwestern Oregon. Pacific Northwest Forest and Range Expt. Sta. Res. Note 144, 5 pp.

Gives panel recovery data from two studies, by log grade and size class.

_____ and Knauss, A. C.
Veneer recovery from peeler grade Douglas-fir logs-no rthwestern Oregon. Pacific Northwest Forest and Range Expt. Sta. Res. Note 148, 5 pp.

Gives panel recovery data from two studies, by log grade and size class.

_____ and Knauss, A. C.
Veneer recovery from Douglas-fir logs. Pacific Northwest Forest and Range Expt. Sta. Res. Paper 23, 13 pp., illus.

Combines panel recovery data for 6 million board-feet of peelable logs in Oregon and Washington, by log grade and size class.

_____ and Knauss, A. C.
Veneer recovery from peeler grade Douglas-fir logs in western Washington. Pacific Northwest Forest and Range Expt. Sta. Res. Note 152, 5 pp.

Gives panel recovery data from two studies, by log grade and size class.

Knauss, A. C.
Seasoning degrade in kiln drying ponderosa pine in south central Oregon. Pacific Northwest Forest and Range Expt. Sta. Res. Note 136, 11 pp.

Shows seasoning and manufacturing degrade losses by specific causes, in percentage and in dollar value.

Matson, E. E.
Western hemlock lumber recovery at a western Washington sawmill. Pacific Northwest Forest and Range Expt. Sta. Res. Note 140, 9 pp., illus.

Gives green-chain lumber grades by log diameters.

_____
White fir lumber recovery in western Washington. Pacific Northwest Forest and Range Expt. Sta. Res. Note 141, 8 pp., illus.

Gives green-chain lumber grades by log diameters.

_____
Western redcedar lumber recovery from a western Washington sawmill. Pacific Northwest Forest and Range Expt. Sta. Res. Note 143, 10 pp., illus.

Gives green-chain lumber grades by log diameters.

Matson, E. E.
Wyssen skyline crane. Pacific Logging Cong. Loggers Handbook (1957) 17:78-79.

Describes operation of a skyline crane on an experimental timber sale on rough ground near Twisp, Wash.

RANGE MANAGEMENT

Costello, David F.
Grasslands. In America's Natural Resources, pp. 61-84. Ed.by Charles H. Callison. New York.

Summarizes the use and influence of grasslands in America from historical times to the present. Describes modern grazing practices in relation to other land uses and looks toward the future development of grazing, water, wildlife, and recreational resources of grasslands.

_____
Application of ecology to range management. Ecol. 38:49-53.

Points out the application of ecological principles to management of a complex range environment, the development of data for economic evaluation, and the formulation of practical guides for wise resource use.

_____
Range management education. V. College training for range management students: an employer's view. Jour. Range Mang't. 10:121-122.

A discussion of desirable attributes in new employees in range management, the place of specialization in career development, and needed college curriculum changes to provide balanced training in the sciences, the humanities, and professional techniques.

_____ and Driscoll, Richard S.
Hauling water for range cattle. U. S. Dept. Agr. Leaflet 419, 6 pp., illus.

Points out advantages of hauling water on arid western ranges and gives suggestions for economical and efficient methods of interest to ranchers and range administrators.

Garrison, G. A.
Mountain summer range. In 1956 Stockmen's Handbook, pp. 177 and 179. Dept. Animal Sci., State Col. Wash., Pullman.

A description and evaluation of various vegetation types in the mountains of central Washington, plus a listing of the management problems inherent to each type of vegetation.

Skovlin, Jon M.
Range riding--the key to range management. Jour. Range Mang't. 10:269-271, illus.

Describes how to achieve good range management through proper range riding.

WATERSHED MANAGEMENT

Bethlahmy, Nedavia, and Barr, George
Bull Run Watershed: Portland's water source. American Forests 63(6):16-18, 62-64; illus.

President Harrison created the Bull Run Reserve in 1892. Events leading to this act and to subsequent ones are reviewed in perspective. The role of watershed research and its importance to the future development of the reserve are discussed.

Miner, Norman H., and Trappe, James M.
Snow interception, accumulation, and melt in lodgepole pine forests in the Blue Mountains of eastern Oregon. Pacific Northwest Forest and Range Expt. Sta. Res. Note 153, 4 pp., illus.

Discusses 1 year's data from snow courses and precipitation gages within a lodgepole pine stand and in adjacent openings.

GENERAL

Cramer, Owen P.
Review of "The Climate Near the Ground" by Rudolf Geiger. Jour. Forestry 55:854.

European microclimatology in 1950 receives detailed and well-organized coverage. Factors that affect plant and forest stands are given greatest attention.

Johnson, Floyd A.
A technique for calculating cubic volumes in butt logs of trees. Jour. Forestry 55:666, illus.

Standard methods for calculating cubic-foot volumes for butt logs of trees are either inaccurate or unwieldy. The method described in this paper is both accurate and easy to apply if a desk calculator is available.

Larsen, A. T., and Buckhorn, W. J.
Visual aids for aerial observers. Pacific Northwest Forest and Range Expt. Sta. Res. Note 149, 4 pp.

Two types of plastic helmets and eleven types of colored glasses were tested under actual flying conditions for reduction of eyestrain and increase in efficiency of observers. As a result of these tests, four types of optical glasses are recommended for use by aerial observers.

Madison, Robert W.
A guide to the Cascade Head Experimental Forest. 13 pp., illus. Pacific Northwest Forest and Range Expt. Sta.

Describes the experimental forest, its purpose and administration, and the research projects in progress.

Pacific Northwest Forest and Range Experiment Station
1957 Annual Report, 107 pp., illus.

Summary of station research accomplishments during calendar year 1956 and plans for 1957.

Pope, R. B.
The effect of photo scale on the accuracy of forestry measurements. Photogrammetric Engin. 23:869-873.

The accuracy of tree height measurement and species identification on both panchromatic and color photos was tested at scales ranging from 1:20,000 to 1:2,500.

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